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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 7, Number 10 October 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Division of Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

DIGEST OF PROTECTION STANDARDS AND STATE REGULATIONS FOR RADIOACTIVITY IN WATER

J. L. S. Hickey[1]

Numerical limits of seven published standards and guides for radium–226, strontium–90, and unidentified radionuclides in water for various applications and population groups are summarized. Of the 54 States and Territories, 47 have legislation or regulations for control of radionuclides in water. Of these, 31 have adopted some form of numerical limits for control of radionuclides in water. Sixteen States and Territories have general legislation permitting control of radiation exposure but no numerical limits for radionuclides in water, and seven have no specific legislation for control of radionuclides in water.

At least seven International and National agencies publish standards, recommendations, or guides for radionuclides in water. Although Tsivoglou and Burke (*1*) have found no basic conflict among these standards and guides, extensive study of several technical publications is required to reconcile differences in the numerical values given.

A listing of the published guides and limits for the radionuclides commonly found in water supplies and sources, as well as a summary of the regulations adopted by the States for these radionuclides in water, has been prepared for use as a reference by public health field personnel responsible for the radiological quality of drinking water and water sources.

The numerical guides and limits which are to be discussed have a variety of applications, and each must be considered on the basis of its intended application as well as on the basis of the numerical values given.

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Radium–226 and strontium–90, because of biological uptake and retention in critical organs, long life, and energetic radiation, are two of the most important radionuclides found in water. Radium–226 is found naturally in some well waters, and strontium–90 is found in surface waters as a result of fallout. This report discusses these nuclides and also unidentified radionuclides. Unidentified radionuclides are included because measurements of gross radioactivity in water are relatively simple screening procedures which can be used to reduce the workload when the volume of samples is large and little radioactivity is anticipated.

Published standards and recommendations

Table 1 lists recommended upper limits for radium–226, strontium–90, and unidentified radionuclides in water, in some cases exclusive of natural background. The values applied to the general population are somewhat lower than the recommended limits of exposure for individuals and for populations near a nuclear facility. Although some values appear several times, the reader should not infer that the median or most frequently occurring numerical values are necessarily the most desirable limits.

Various facets of these limits are discussed in the following text, with emphasis on application to the general population. In these discussions, the agencies are referred to by the initials shown in table 1, and the references are those in table 1 except where indicated otherwise.

Point of application of limits: The values shown in table 1 are intended to establish limits for human exposure to radioactive materials, and several of the recommendations apply at the point of human intake. However, the Atomic Energy Commission (AEC) regulations, the Council of State Governments (CSG) recommendations, and the National Committee on Radiation Protection (NCRP) suggested radiation protection regulations generally pursue this objective by limiting the radioactivity levels in effluents discharged into unrestricted areas.

These three agencies permit discharge of radioactivity in excess of the limits shown in table 1 if it can be demonstrated that human exposure limits will not be exceeded. They also provide for more stringent limits on effluents discharged to unrestricted areas where circumstances warrant; for example, if several installations discharging radionuclides to the same stream resulted in possible human exposure above the recommended limits.

FRC recommendations: The Federal Radiation Council (FCR) guidance for intake of radionuclides is different from the others in that it is based on total daily intake from all sources except natural background. The intake guides recommended by the FRC cover three broad ranges. The FRC recommends that "routine control of useful applications of radiation and atomic energy should be such that expected average exposures of suitable samples of an exposed population group will not exceed the upper value of Range II." These values are 20 pCi/day for radium–226 and 200 pCi/day for strontium–90. The limits per liter shown in table 1 for the FRC were derived from the above

Table 1. Summary of standards and guides for radium-226, strontium-90, and unidentified radionuclides in water

Point of nuclide measurement	Agency (and reference number)	Applicable population group	Upper-limit, pCi/liter		
			Radium-226	Strontium-90	Unidentified
At point of human ingestion (drinking water system)	International Commission on Radiological Protection (ICRP) (*2, 3*)	Any individual	10	400	10
	National Committee on Radiation Protection; Suggested Radiation Protection Regs. (*4*)		10	100	—
	U.S. Public Health Service Drinking Water Standards (PHS) (*6*)	General population	3	10	—
	World Health Organization (WHO) (*8*)		10	30	—
	ICRP (*2, 3*)		3.3	133	3.3
	ICRP (*2, 3*)	Population near a nuclear facility	10	400	10
	National Committee on Radiation Protection (NCRP) (*10*)		10	100	10
Assay of reasonable aliquot of total intake	Federal Radiation Council (FRC) (*7*)	Suitable sample of an exposed population group	[a] 9	[a] 90	—
In effluent water at point of discharge to unrestricted areas	U.S. Atomic Energy Commission (AEC) (*5*)	Any individual [b]	30	300	30
	Council of State Governments: Suggested State Regulations for Control of Radiation, April 1966 Revision (CSG) (*9*)		30	300	30
	CSG—1964 Edition (*11*)		10	100	10
	NCRP Suggested Radiation Protection Regs. (*4*)		10	100	—
Annual average intake measured at point of ingestion	AEC (*5*)	Suitable sample of exposed population [c]	10	100	10
	CSG—1966 Revision (*9*)		10	100	10

[a] Derived from FRC guides for total intake per day of 20 pCi of ^{226}Ra and 200 pCi of ^{90}Sr, assuming a dietary intake of 2,200 g/day total water and food (*2*), containing equal concentrations of these radionuclides, and no other radiation exposure above that from natural background.

[b] Discharge limits may be raised if no individual is thus exposed to radioactivity levels in water greater than limits shown.

[c] Discharge limits may be lowered if necessary to prevent exposure of the population to radioactive intake greater than the intake resulting from continuous exposure to water containing the concentrations shown.

values assuming a daily intake of 2,200 grams of water and food (*2*) containing equal concentrations of these radionuclides and no other radiation exposure above that from natural background.

Application of guides: AEC regulations are binding on their licensees. Public Health Service (PHS) Drinking Water Standards are binding on interstate carriers and others subject to Federal quarantine regulations. The FRC develops Federal policy on human radiation exposure consistent with an orderly development of the application of nuclear energy and ionizing radiation. A major function of the FRC is to guide "all Federal agencies in the formulation of radiation standards and in the establishment and execution of programs of cooperation with States" (*12*). The other published limits shown in table 1 are recommendations of each organization.

Radioactivity in water in relation to total exposure: Values given by the International Commission on Radiological Protection (ICRP), NCRP, AEC, FRC, and CSG for limiting exposure to radioactivity from drinking water apply, either expressly or by implication, where there is no other significant source of internal radiation exposure, such as from air or food above that received from natural background. A formula has been adopted by some of the agencies for reducing limits in cases of exposure from more than one radionuclide. Under this formula, the sum of the concentrations of all radionuclides taken internally, each divided by its own limit, may not exceed the value of one (unity).

The World Health Organization (WHO) and PHS standards for drinking water allow for additional radiation exposure from other sources, such as from air and food. They should therefore be considered as guidance levels rather than as upper limits. The PHS standards are formulated on the basis that if these levels are not exceeded, water supplies shall be approved without further consideration of other sources of intake of these radionuclides. The PHS standards also state that "when these concentrations (*i.e.*, 3 pCi/liter of radium–226 and 10 pCi/liter of strontium–90) are exceeded, a water supply shall be approved by the certifying authority if surveillance of total intake of radioactivity from all sources indicates that such intakes are within the limits recommended by the Federal Radiation Council for control action" (*6*). These limits are 20 pCi/day for radium–226 and 200 pCi/day for strontium–90 above that received from natural background (*7*).

The WHO limits in table 1 should also be interpreted as levels which "are merely intended to indicate that, if the levels are lower than those given, then the water is safe for use without further investigation" (*8*).

Natural background: The limits in table 1 for AEC, NCRP, CSG, ICRP, and FRC are for exposure above "natural background" and therefore could be interpreted as not applying to naturally occurring radioactivity in water in any amount. This presents a situation in which the judgment of persons responsible for the radiological quality of drinking water could play a large role in the application of the guides —as in determining whether, for example, 20 pCi/liter of naturally occurring radium–226 in a well water supply should be classed as natural background. ICRP specifies that its recommendations exclude background only when it is insignificant. The PHS and WHO recommended limits include internal exposure from naturally occurring radioactivity.

Soluble and insoluble nuclides: The limits given in table 1 for NCRP, ICRP, CSG, AEC, and NCRP suggested State regulations are for soluble radionuclides. Permissible limits for insoluble radionuclides range up to 3,000 times higher for radium–226 and up to 400 times higher for strontium–90, reflecting a smaller probability of assimilating the radionuclides when in the insoluble state. WHO, PHS, and FRC limits do not specify the soluble or insoluble state.

Unidentified radionuclides: The limits for unidentified radionuclides in water generally coincide with those for soluble radium–226. This in effect means that any unidentified radionuclide is presumed to be soluble radium–226, which has a lower allowable limit than any

other nuclide in water. Where total radioactivity in water is very low, gross radiation counts can be used to demonstrate this, and make more detailed analyses unnecessary.

Discharge to sanitary sewers: AEC and CSG standards for radionuclide levels in wastes discharged directly to sanitary sewers are given in table 2. These are from 40 to 100 times higher than the limits in table 1. AEC and CSG standards specifically exempt wastes discharged to sanitary sewers from the limits placed on other effluents discharged to unrestricted areas. Instead, the average monthly radionuclide concentrations in the total sanitary sewer flow leaving a licensee's installation are limited to the values in table 2.[2] Sufficient additional dilution

Table 2. Limits for discharge of soluble radium-226, strontium-90, and unidentified radionuclides into sanitary sewers [a]

Source of standard	Limit, pCi/liter		
	Radium-226	Strontium-90	Unidentified
U.S. Atomic Energy Commission Regulations (5)	400	10,000	400
Council of State Governments: Suggested State Regulations for Control of Radiation, 1966 (9)	400	10,000	400
Council of State Governments: Suggested State Regulations for Control of Radiation, 1964 Edition (11)	400	4,000	300

[a] Measured at point of leaving licensee's installation

of these wastes will ordinarily occur before they are capable of exposing the public, such as by contamination of a stream used as a drinking water source. Because the extent of dilution will vary, there is a large area for judgment on the part of the responsible persons in applying these limits.

Average sample values: In determining average radionuclide levels in drinking water for application of the guides and standards, all the agencies suggest that sample results be averaged over a 1-year period, except the ICRP, WHO, and NCRP suggested regulations which recommend quarterly averaging of samples.

[2] In addition, AEC licensees are limited to a total discharge of 1 curie per year (10 CFR 20.303 b2d).

State regulations

Table 3 summarizes State regulations on standards for radionuclides in water. Of the 54 States and Territories, 47 have specific legislation or regulations enabling them to control radioactivity in water. Of these, 31 have adopted some form of numerical limits for radionuclides in water, 16 do not have specific limits for radionuclides in water, and 7 have no specific legislation applicable to control of radiation exposure from water.

Thirteen States have adopted regulations similar to that recommended by the CSG (1964 edition). Seven have adopted NCRP recommendations as given in the National Bureau of Standards Handbook 69 by reference; of these, three specify "current" NCRP recommendations, and thus automatically update their standards to conform with new NCRP recommendations. Three States which specifically adopted either the 1957 AEC regulations or the NCRP recommendations in NBS Handbook 52 and 59 (*13,14*) still retain them.

Table 3. Summary of State regulations for control of exposure of the population to radioactivity in water

Number of States or Territories [a]	Type of regulations
13	Substantially same as Council of State Government 1964 recommendations
7	NCRP Standards: NBS Handbook 69
5	Substantially same as NCRP suggested radiation protection regulations
2	Current AEC standards adopted by reference
3	1957 AEC or NBS Handbooks 52 and 59 standards
1	AEC continuous occupational exposure standards reduced by factor of 10
16	General legislation to control exposure but no numerical standards
7	No specific applicable legislation

[a] Includes D. C., Puerto Rico, Guam, and Virgin Islands.
Sources: Atomic Energy Law Reports (*17*) and most recent State publications.

Interpretation of samples

In monitoring water supplies or sources for radioactivity, the basic health goal is to determine the radioactivity actually ingested by human beings. It is therefore important that samples be representative of the water consumed by the populace. Generally, treated water collected from representative locations may be composited over a 3-month period to obtain representative samples for radiological analysis.

This is possible whenever the significant radionuclides have long half-lives. Since the radionuclide concentrations may vary within a distribution system, care must be taken in choosing sampling locations.

Analyses of raw water, either surface or ground, should be viewed in light of the type of treatment to be provided, as conventional or ion exchange treatment may remove as much as 95 percent of the contained radioactivity (*15*).

Considerations in setting of standards

The critical organ in the body for both radium–226 and strontium–90 is the skeleton. Experience with radiation damage to the human skeleton is largely limited to cases in which large amounts of radium (or thorium) were ingested by adults, through either occupational exposure or medication. This experience has played a large role in the development of standards for internal radiation exposure.

Since the several current standards and guides for radium–226 exposure from drinking water are substantially of the same magnitude, only one, the FRC standard, will be reviewed here for an understanding of the factors considered in establishing these standards and guides, and as a basis for estimating the factor of reduction built into the standards below that exposure from radium–226 in drinking water which might be expected to result in detectable damage to the body.

Based on experience with radium–226 damage, the NCRP set the maximum body burden for radium–226 at 0.1 μCi (*13*), a value which had been in use since 1941. The FRC (*7,12*) adopted 0.1 μCi of radium–226 in the skeleton as the radiation protection guide for radiation workers, noting that detectable skeletal damage had occurred in adults who had a residual radium body burden of 0.5 μCi. The upper limit of the FRC Range II transient rate of daily intake of 20 pCi/day was considered to be a dose which at equilibrium would result in a body burden not exceeding 1/100 of that permitted in radiation workers, or a body burden of 0.001 μCi of radium–226 for the average of a suitable sample of an exposed population group, or of 0.003 pCi for individuals in the general population.

Evans (*16*) points out that skeletal radium damage observed in humans has largely been due to radium–226 ingestion over a short period of time which resulted in a residual body burden of about 0.5 μCi, rather than due to chronic ingestion of small doses which eventually reached a body burden of about 0.5 μCi. He estimates that this results in a "silent safety factor" of 15 in the radiation protection guide for the radiation worker. This, combined with the factor of 100 mentioned previously, results in the FRC's guide for radium–226 exposure in the general population being 1,500 times lower than that which has been observed to lead to detectable skeletal damage.

This factor may, of course, not be fully applicable because of variations in population intake and the possibility of more subtle biological damage at lower body burdens of 0.1 nCi. Because of these uncertainties, all agencies publishing standards subscribe to the basic concept that radiation exposure to the populace be kept as low as possible, and that, in the words of the NCRP, "the goal should be no radioactive contamination of air and water and of the body if it can be accomplished with reasonable effort and expense" (*13*).

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PRECISION AND SENSITIVITY OF GAMMA SPECTROMETRIC MEASUREMENTS IN MILK

M. A. Wall and *A. S. Goldin*[1]

The sensitivity and precision of a gamma spectrometric laboratory for routine milk samples comprising four similar detector-analyzer systems was studied, utilizing the results obtained on environmental fluid milk samples. The sensitivity of the system was evaluated by measurements of iodine–131 concentrations, mostly at the zero counting level. The precision of the system was measured on the basis of replicate determinations of potassium and cesium–137 at higher counting levels.

At all levels studied, variability was not significantly different from that calculated from radioactivity statistics. Only at the highest level encountered was there any indication of a greater variability than would be expected on a statistical basis, and even at this level the difference was not significant at the 95-percent confidence level.

It is well established that the radioactive disintegration process occurs in a random manner in such a way that the number of disintegrations—and also the number of counts observed in a given period of time—vary in a way that is described by the Poisson distribution. This variation has been generally used as a basis for calculating the error of radionuclide determinations or, rather, that portion of the error attributable to "counting statistics."

In the laboratories of the Division of Radiological Health, as in many other laboratories, gamma spectrometry is used for the direct measurement of a number of nuclides in various media. In the general case, a gamma spectrum consists of a linear combination of nuclide spectra superimposed on a background spectrum.

Spectra must be mathematically analyzed in some way in order to determine the concentration of the gamma-emitting nuclides in the sample. At the Northeastern Radiological Health Laboratory, the spectra are analyzed by assigning to each nuclide a characteristic energy region, usually the region of the full-energy peak of one of its gamma photons, correcting for the contribution of other nuclides to this region, and then calculating the nuclide concentrations from calibration spectra.

As in any analytical procedure, it is important to know the precision, sensitivity, and accuracy of the method. This paper presents a method for the calculation of counting error and compares the actual precision, computed from replicate determinations, with the calculated counting errors at several levels. The determinations of iodine–131, cesium–137, and potassium in milk are used as examples.

Fundamentals

1. The number of counts N observed in a given counting period follows the Poisson distribution with mean $\bar{N}$ and variance $\bar{N}$.

2. The *gross* counting rate R_0 observed in a given counting period t_0 follows approximately a normal distribution with mean $\bar{R}_0$ and variance $\bar{R}_0/t_0$. The rate $\bar{R}_0$ is equal to $\bar{N}/t_0$.

3. The *net* (gross minus background) counting rate R (where $R = R_0 - R_b$) follows approximately a normal distribution with mean $\bar{R}$ and variance $(R_0/t_0 + R_b/t_b)$. Here R_0 and R_b are the gross and background counting rates, respectively, observed over the times t_0 and t_b.

[1] Mrs. Wall is a statistician and Dr. Goldin is deputy officer in charge at the Northeastern Radiological Health Laboratory, Division of Radiological Health, Public Health Service, Winchester, Massachusetts 01890.

The activity of each of the nuclides in milk can be analytically expressed (*1*) as:

$$^{131}I: G_I = I + C_I C + L_I L + K_I K + B_I \quad (1)$$

$$^{137}Cs: G_C = I_C I + C + L_C L + K_C K + B_C \quad (2)$$

$$^{140}Ba: G_L = I_L I + C_L C + L + K_L K + B_L \quad (3)$$

$$^{40}K: G_K = I_K I + C_K C + L_K L + K + B_K \quad (4)$$

The nomenclature for these equations is given below:

Item	Spectral region for			
	Potassium-40	Iodine-131	Cesium-137	Barium-140
Gross activity (cpm) in:	G_K	G_I	G_C	G_L
Background (cpm) in:	B_K	B_I	B_C	B_L
Fractional coefficient of potassium-40 in:	1	K_I	K_C	K_L
Fractional coefficient of iodine-131 in:	I_K	1	I_C	I_L
Fractional coefficient of cesium-137 in:	C_K	C_I	1	C_L
Fractional coefficient of barium-140 in:	L_K	L_I	L_C	1
Net activity (cpm) of each nuclide in its spectral region:	K	I	C	L

The net activities of each nuclide can then be expressed by equations of the form:[2]

$$I = a_I(G_I - B_I) + b_I(G_L - B_L) + c_I(G_C - B_C) + d_I(G_K - B_K) \quad (5)$$

which are obtained by the simultaneous solution of equations (1) to (4). At NERHL, the gamma spectra of 3.5-liter milk samples in Marinelli beakers are obtained with 4- by 4-inch NaI (thallium) crystals and 200-channel analyzers covering the range 0 to 2 MeV (10 keV per channel). Counting time is 50 minutes. The G's of equation (5) are obtained from these spectra. Backgrounds are measured by counting 3.5-liter samples of distilled water in the identical configuration, giving the B's of equation (5). The coefficients of equations (1) to (4) are obtained from gamma spectra of standard solutions of each nuclide, again in the same configuration.

The standard deviation of 1 (or of any other of the nuclide counting rates) is calculated from equation (5) by conventional propagation-of-error techniques, since all the G's and B's are statistically independent. In this treatment, the coefficients are treated as being without error. In fact, however, there is an error associated with these coefficients from statistical considerations and from differences in conditions between the "standard" runs and the "sample" runs. The statistical errors in the standards are reduced to negligible proportions by accumulating sufficient counts in each standard run. Other errors are minimized by controlling ambient conditions and sample volumes, and by maintaining precise control of the instrumentation.

In spite of these precautions, it is clear that there must be, at least in theory, differences in conditions from run to run. Some of the causes of these differences, without any attempt to be exhaustive, would include non-identity of sample breakers, non-identity of ambient conditions, change in crystal response or photomultiplier gain with time, and analyzer drift.

Sensitivity

The term sensitivity as used in the discussion refers to the minimum detectable activity which is defined as that measurement which is significantly greater than zero at the 95-percent confidence level. When defined in this way, it is equivalent to Altshuler's (*2*) "minimum significant measured activity."

The estimate of the variance, s^2, in a single measurement of the concentration of iodine–131 in a milk sample is

$$s^2 = a^2_I s^2_I + b^2_I s^2_L + c^2_I s^2_C + d^2_I s^2_K \quad (6)$$

where

$$s^2_I = \text{variance of } (G_I - B_I) = (G_I + B_I)t$$

with similar equations for the other s^2's. The counting time, t, is 50 minutes throughout, and s is in counts per minute.

The error in measuring a value for iodine–131 when the concentration was actually zero was calculated. In these calculations, a concentration of 1.5 grams of potassium per liter and various concentrations of cesium–137 and barium–140 was assumed. The calculations are

[2] Where a, b, c, and d are constants for the specific nuclide.

summarized in figure 1. It may be observed that the error is virtually independent of the cesium–137 concentration up to 100 pCi/liter, and is increased by less than 1 pCi/liter at cesium–137 concentrations up to 300 pCi/liter. Barium–140 has a greater effect on the error, but fortunately this nuclide is present in high concentrations in milk samples only when the iodine–131 content is also high.

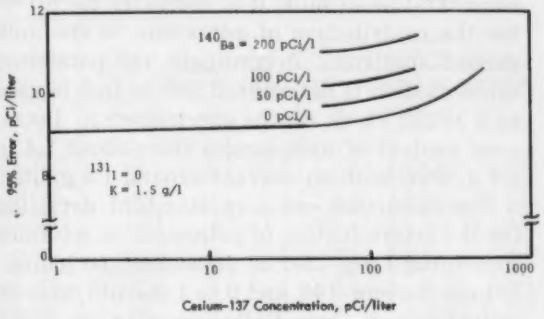

Figure 1. Calculated counting error for zero-level iodine–131

The measured iodine–131 contents of 94 milk samples analyzed during July 1963 are listed in table 1. During this time, the concentrations of barium–140, cesium–137, and potassium were, respectively, 0 pCi/liter, 95 to 410 pCi/liter, and approximately 1.5 g/liter. Since there was no atmospheric nuclear weapons testing during this time, the concentration of iodine–131 in these samples could be assumed to be zero. Figure 1 indicates that the error at the 95-percent confidence level for iodine–131 in these samples should be between 9.4 and 10.3 pCi/liter.

Table 1. Iodine-131 contents of 94 milk samples analyzed during July 1963, pCi/liter

1.4	−1.8	5.3	−7.1	−6.1
−8.6	−1.7	5.7	7.3	2.4
0.7	−1.0	−7.5	−1.3	2.2
−15.4	5.9	6.2	−0.2	4.1
3.6	4.1	−0.5	0.7	4.3
−7.0	0.1	3.0	−2.2	3.8
−7.5	3.4	−1.0	−0.1	−11.7
−0.3	3.2	1.9	−6.2	6.0
13.4	−3.7	1.1	−1.4	−7.0
3.0	−2.5	−4.8	5.5	2.4
−6.1	−4.8	−0.4	−6.3	−1.2
−9.1	−3.1	−9.7	0.9	−5.0
4.9	−6.2	−2.2	1.6	2.1
2.1	−3.4	1.6	17.6	−4.7
8.2	4.3	3.3	−2.7	1.1
−7.1	0.4	−1.6	−1.0	−6.0
7.3	−0.5	−2.0	−4.6	1.3
1.4	−1.1	2.8	3.1	−4.8
−1.4	0.2	−7.5	−2.1	

The 94 pieces of data of table 1 were used to test the following hypothesis: "the distribution of observed iodine–131 levels in milk, during this period, was normal with mean 0 pCi/liter, and standard deviation 5 pCi/liter." The mean and standard deviation of the observed values were –0.5 and 5.2 pCi/liter, respectively. Application of the t and χ^2 tests (*3*) confirmed that these values were not significantly different from those of the hypothesis.

$$t = (\bar{x} - \mu)/\sigma_{\bar{x}} = \frac{(-0.5) - (0)}{5/\sqrt{94}} = -0.97;$$

$$P(|t| \leq .97) < 70\% \quad (7)$$

$$\chi^2 = ns^2/\sigma^2 = \frac{94(5.2)^2}{(5.0)^2} = 101.67;$$

$$P(\chi^2 \leq 101.67) < 75\% \quad (8)$$

For visual observation, the 94 values are presented as a graph on normal probability paper (figure 2), which indicates that the data are distributed normally. As a further check,

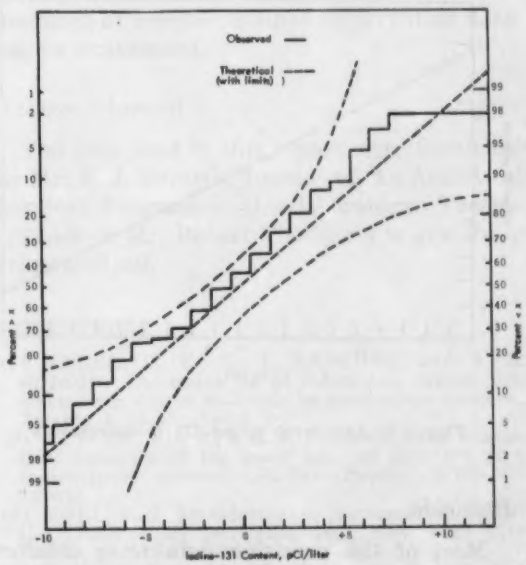

Figure 2. Cumulative frequency function, iodine–131 in milk, July 1963

the goodness of fit to the normal line was tested by the Kolmogorov-Smirnov test (*4*). From all these tests, the hypothesis that the data are normally distributed with mean zero and standard deviation 5 pCi/liter can be accepted, leading to the conclusion that any result for iodine–131 greater than 10 pCi/liter is significantly different from zero at the 95-percent confidence level and that this is therefore the sensitivity of the determination.

In order to supplement the data on sensitivity obtained at an iodine–131 concentration of zero, samples containing small known quantities of iodine–131 in the presence of ordinary concentrations of cesium–137 and potassium were prepared and measured. The cesium–137 and potassium concentrations were 119 pCi/liter and approximately 1.6 g/liter, respectively. The sample was counted 10 times over a period of 2 weeks. The data are shown in figure 3. The known iodine–131 activity is shown as the straight line, indicating its exponential decay. It is obvious that the points are close to the known values, indicating that the accuracy at low levels for iodine–131 is acceptable.

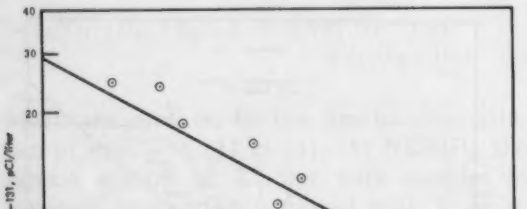

Figure 3. Low-level iodine–131 measurements

Precision

Most of the precision data were obtained from the average range of duplicate determinations which form the backbone of an internal quality control program. One out of five samples, taken randomly, is resubmitted to the counting room for gamma spectrometry as a "blind" duplicate: that is, it is submitted with a new number as a fresh sample. The data presented deal with values of potassium and cesium–137 which were the only gamma-emitting nuclides regularly present during the period November 1962 to November 1964.

Potassium. Although there is of course no radiological health interest in the potassium concentration of milk, it is necessary to correct for the contribution of potassium to the milk gamma spectrum. Accordingly, the potassium concentration is determined and in fact is used as a rough check on the spectrometry. Potassium content of milk ranges from about 1.4 to 1.8 g/liter, with an average around 1.5 g/liter.

The calculated counting standard deviation for the determination of potassium in solutions containing 1.5 g/liter of potassium, no iodine–131 nor barium–140, and 0 to 1,000 pCi/liter of cesium–137 is essentially constant at 0.065 g/liter.

This calculated standard deviation was compared with the observed standard deviation obtained from range measurements of 307 duplicate analyses. The mean range was found to be 0.0678 g/liter. The standard deviation corresponding to this mean range is 0.0601 g/liter. Confidence limits for the estimate of the standard deviation calculated from the mean range may be computed from the formula (*5*):

$$\frac{0.886\bar{R}}{1+z_\alpha\sqrt{0.571/n}}<\sigma<\frac{0.886\bar{R}}{1-z_\alpha\sqrt{0.571/n}} \qquad (9)$$

where

n = number of duplicate tests,
z_α = normal ordinate for confidence level α, and 0.886 and 0.571 are factors for sample sets of two observations.

The value of σ from equation (9), making the proper numerical substitutions, is between 0.0554 and 0.0656, in agreement with the value calculated from counting statistics. Therefore, at the level of 1.5 grams of potassium per liter of milk, the precision is controlled by counting statistics.

Cesium–137. A total of 458 sets of duplicate determinations of cesium–137 in milk were examined. The concentration in these samples varied from 50 to 500 pCi/liter. In order to perform the statistical analysis, the data were grouped according to concentration as shown in table 2. For each concentration the limits

Table 2. Comparison of theoretical and observed error in cesium-137 determinations

Cesium-137 (pCi/liter)	Midpoint (pCi/liter)	Number in group	Average range (pCi/liter)	Observed standard deviation (pCi/liter)	95-percent confidence level for standard deviation (pCi/liter)	Theoretica standard deviation (pCi/liter)
50–100	75	189	5.9	5.2	4.7–5.9	5.3
100–120	110	52	5.4	4.8	4.0–6.0	5.6
120–140	130	73	6.9	6.1	5.2–7.4	5.7
140–160	150	44	7.4	6.6	5.4–8.5	5.8
160–180	170	38	7.2	6.4	5.1–8.4	6.0
180–200	190	14	8.9	7.9	5.7–13.1	6.1
200–220	210	11	6.8	6.0	4.2–10.9	6.3
220–240	230	7	6.3	5.6	3.4–12.7	6.4
240–260	250	11	7.1	6.3	4.3–11.4	6.5
260–280	270	5	6.6	5.8	3.5–17.3	6.6
280–480	380	14	10.8	9.6	6.9–15.8	7.3
	1,000					10.2

of the observed standard deviation, calculated from the range, were compared with the theoretical standard deviation based on counting statistics. The latter were calculated from the basic equation (6). The results of these analyses are depicted in figure 4. This graph shows

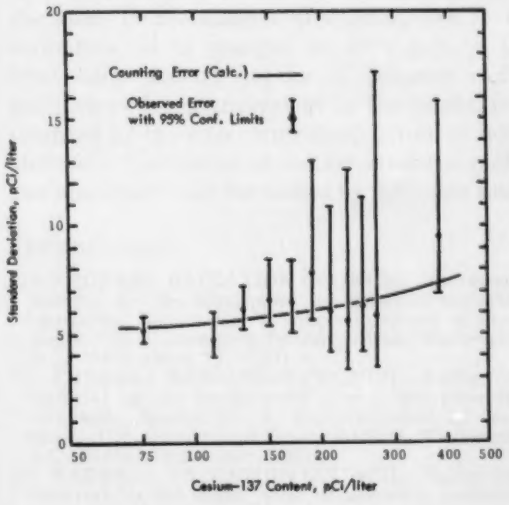

Figure 4. Calculated and observed errors in cesium–137 determinations

that the observed data fall close to the theoretical line over the range 50 to 280 pCi/liter, with no trend from the theoretical. Even at the highest level, 280 to 480 pCi/liter, there is no significant increase over the theoretical error at the 95-percent confidence level. It is possible that at this level, where the counting error is only about 2 percent, measurement errors are becoming noticeable. Because of the small number of duplicate analyses at this level, it was not possible to investigate further.

Conclusion

In the particular counting configuration described in this paper, which is in general use throughout the laboratories of the Division of Radiological Health, it has been found that the errors calculated from theoretical statistical considerations represent the total analytical error for milk samples containing radionuclides at environmental levels. The limits of precision and sensitivity for these measurements are, in fact, those which are calculated from the theoretical considerations. Assuming that adequate steps are taken to insure instrument stability (*i.e.*, daily calibration check with standard and daily background check), the precision of results obtained on a routine basis can be guaranteed.

Acknowledgment

The data used in this report were furnished by Mr. E. J. Baratta, director of the Analytical Services Program at this laboratory. The assistance of Mr. Robert Thompson is gratefully acknowledged.

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(*4*) MASSEY, F. J., JR. The Komogorov-Smirnov test for goodness of fit. J Am Stat Assn 46:68f (1951).

(*5*) DIXON, W. J., and F. J. MASSEY, JR. Introduction to Statistical Analysis. McGraw-Hill Book Co., Inc., New York City (1957), p. 84.

ERRATUM. An erroneous statement appears in the report "Maine's Experience with a State-operated Personnel Monitoring Program for Radiation Workers," by J. W. Fuller (Radiol Health Data Rep 7:489–492, September 1966). The statement on page 490, "It was observed that beyond a 3-year period, the image on these film badges begins to fade; and after 5 years, the image had faded so badly that the value of the film as a record is very questionable" is incorrect. Actually, there was insignificant fading of the image on the majority of the film badges over the 10-year period.

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the United States population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; however, they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5,6*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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NATIONAL AND INTERNATIONAL SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk.

In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	July–December 1965	June 1966

1. Pasteurized Milk Network June 1966

Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 issue of *Radiological Health Data* (*1*).

The results for June 1966 and for the second quarter of 1966 are presented in table 1. The average monthly radionuclide concentrations

Figure 1. Pasteurized Milk Network sampling locations

Table 1. Average concentrations of radionuclides in pastuerized milk for the second quarter and June 1966 [a]

Sampling locations		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)		Iodine-131 (pCi/liter)		Barium-140 (pCi/liter)	
		Second quarter[b] 1966	June 1966	Second quarter 1966	June 1966	Second quarter 1966	June 1966	Second quarter 1966	June 1966	Second quarter 1966	June 1966
Ala:	Montgomery		10	12	12	25	25	10	10	0	0
Alaska:	Palmer		<5	15	17	40	35	0	0	0	0
Ariz:	Phoenix		<5	3	4	10	10	0	0	0	0
Ark:	Little Rock		35	32	31	40	40	40	30	10	20
Calif:	Sacramento		<5	9	8	15	15	0	0	0	0
	San Francisco		<5	9	7	20	15	0	0	0	0
C.Z:	Cristobal		5	4	4	20	20	0	0	0	0
Colo:	Denver		<5	11	11	25	25	0	0	0	0
Conn:	Hartford		5	13	15	40	40		0	0	0
Del:	Wilmington		5	17	16	40	30	0	0	0	0
D.C:	Washington		5	13	14	30	30	0	0	0	0
Fla:	Tampa		<5	10	10	125	135	0	10	0	0
Ga:	Atlanta		15	20	21	40	45	10	10	0	10
Hawaii:	Honolulu		<5	6	6	30	25	0	0	0	0
Idaho:	Idaho Falls		<5	14	12	40	35	0	0	0	0
Ill:	Chicago		<5	13	13	35	25	0	0	0	0
Ind:	Indianapolis		15	13	14	30	25	20	20	0	0
Iowa:	Des Moines		25	16	17	30	25	10	20	0	0
Kans:	Wichita		10	14	14	20	20	20	30	0	10
Ky:	Louisville		15	19	19	20	20	0	0	0	0
La:	New Orleans		10	32	34	45	50	0	10	0	0
Maine:	Portland		10	16	15	70	65	0	0	0	0
Md:	Baltimore		10	15	17	30	35	0	0	0	0
Mass:	Boston		5	17	20	60	60	0	0	0	0
Mich:	Detroit		<5	12	11	30	25	0	0	0	0
	Grand Rapids		<5	16	17	45	35	0	0	0	0
Minn:	Minneapolis		10	23	26	40	35	0	10	0	0
Miss:	Jackson		20	26	26	30	35	10	20	0	10
Mo:	Kansas City		35	17	19	25	25	30	30	0	10
	St. Louis		55	19	23	30	30	30	40	0	10
Mont:	Helena		<5	14	13	55	40	0	0	0	0
Nebr:	Omaha		20	15	17	30	25	10	20	0	0
Nev:	Las Vegas		<5	6	6	25	25	0	10	0	0
N.H:	Manchester		<5	17	18	80	85	0	0	0	0
N.J:	Trenton		<5	13	14	30	30	0	0	0	0
N. Mex:	Albuquerque		<5	6	6	20	20	0	20	0	0
N.Y:	Buffalo		<5	12	15	40	30	0	0	0	0
	New York		10	15	17	40	40	0	0	0	0
	Syracuse		<5	13	13	40	30	0	0	0	0
N.C:	Charlotte		15	20	21	30	35	20	20	0	0
N. Dak:	Minot		<5	34	31	40	35	0	0	0	0
Ohio:	Cincinnati		10	15	14	25	20	0	0	0	0
	Cleveland		5	14	14	35	25	0	0	0	0
Okla:	Oklahoma City		20	14	14	20	20	20	30	0	10
Ore:	Portland		<5	14	15	40	40	0	0	0	0
Pa:	Philadelphia		<5	14	14	35	30	0	0	0	0
	Pittsburgh		<5	19	21	45	40	0	0	0	0
P.R:	San Juan		<5	8	8	25	25	0	0	0	0
R.I:	Providence		<5	15	19	45	45	0	0	0	0
S.C:	Charleston		15	21	23	50	55	20	20	0	10
S. Dak:	Rapid City		<5	21	18	45	40	0	20	0	10
Tenn:	Chattanooga		10	21	22	30	30	0	0	0	10
	Memphis		15	19	19	20	20	20	20	0	10
Tex:	Austin		<5	6	6	15	15	0	10	0	0
	Dallas		15	16	15	25	20	20	20	0	10
Utah:	Salt Lake City		<5	12	12	35	35	0	10	0	0
Vt:	Burlington		5	14	15	50	40	0	0	0	0
Va:	Norfolk		10	16	17	30	30	0	0	0	0
Wash:	Seattle		<5	18	21	55	55	0	0	0	0
	Spokane		<5	18	18	40	40	0	10	0	0
W. Va:	Charleston		5	17	17	20	20	0	0	0	0
Wis:	Milwaukee		5	10	10	40	30	0	0	0	0
Wyo:	Laramie		<5	12	13	30	35	0	0	0	0
Network average			10	15.2	15.7	36	34	5	7	0	2

[a] Calcium analyses were discontinued as of March 1966.
[b] Quarterly averages are not reported since monthly averages for April were not calculated, as only 10 percent of the samples were analyzed for strontium-89.

are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable value, except for iodine–131 and barium–140, where zero was used for averaging purposes.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 2 and 3 for June 1965 and for January

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations June 1965 and January–June 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965	1966					
	June	Jan	Feb	Mar	Apr	May	June
Under 10	7	10	9	9	8	10	9
10–19	21	46	46	44	50	38	41
20–29	29	6	7	7	3	12	10
30–39	4	1	1	3	2	3	3
40–49	2	0	0	0	0	0	0

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations June 1965 and January–June 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965	1966					
	June	Jan	Feb	Mar	Apr	May	June
Under 50	19	57	56	56	55	51	56
50–99	38	5	6	6	7	11	6
100–149	5	1	1	1	1	1	1
150–199	1	0	0	0	0	0	0

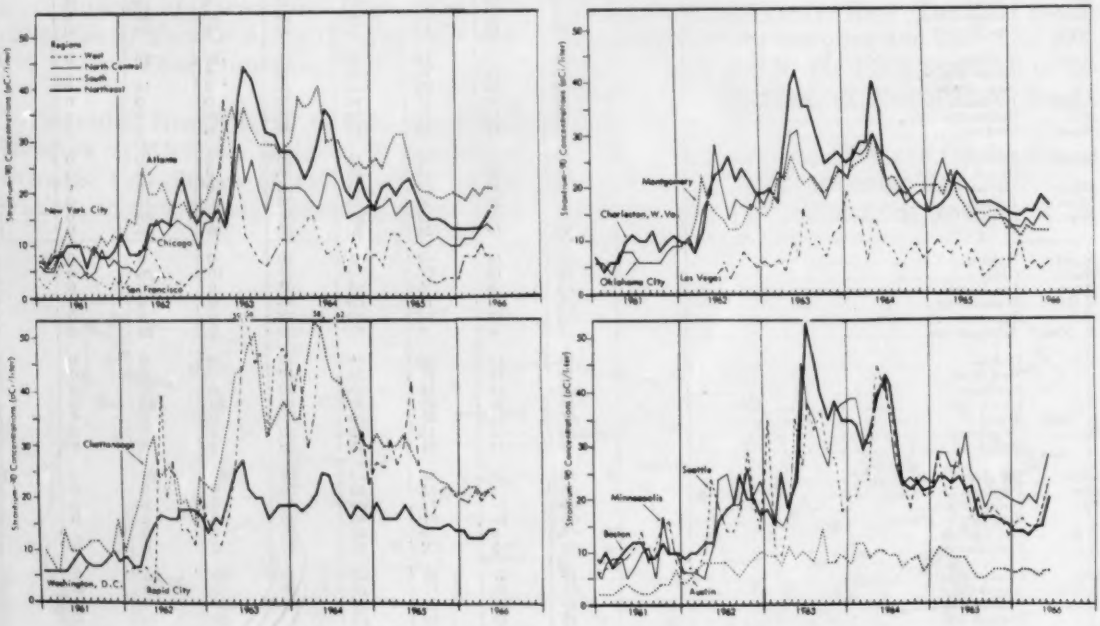

Figure 2. Strontium–90 concentrations in pasteurized milk, 1961—June 1966

Table 4. Daily iodine-131 concentrations in pasteurized milk, June 1966

Sampling location		Daily iodine-131 concentrations, pCi/liter																												
		June 1966																												
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ala:	Montgomery		38							21				<10			<10				<10			<10						
Alaska:	Palmer			<10				<10																						
Ariz:	Phoenix			<10				<10			<10				<10			<10				<10			<10					
Ark:	Little Rock			9				48			38				<10			<10			<10				<10					
Calif:	Sacramento			<10					<10		<10				<10			<10												
	San Francisco			<10											<10		<10					<10			<10					
C.Z.:	Cristobal																													
Colo:	Denver			<10				<10			<10				10		<10					20			<10					
Conn:	Hartford			18				<10			<10				<10			<10				<10			<10					
Del:	Wilmington			29				13			<10				<10		<10					<10			<10					
D.C.:	Washington		14					10		<10					<10		<10													
Fla:	Tampa	47		18				18			<10			<10				<10				<10			13					
Ga:	Atlanta			49				20			14				<10			<10				<10			10					
Hawaii:	Honolulu			<10				<10			<10				<10			<10				<10			<10					
Idaho:	Idaho Falls			<10				<10			<10				20			<10				<10			<10					
Ill:	Chicago			1t				22		<10					<10		<10					<10		<10						
Ind:	Indianapolis			50			35				18			24				20			<10				<10					
Iowa:	Des Moines			40				30			30				30			20				<10			<10					
Kans:	Wichita			80				50			30				10			30												
Ky:	Louisville			20				13			<10				15			<10				<10		<10						
La:	New Orleans			45				25			<10				<10		<10					<10			17					
Maine:	Portland		<10				<10			<10				<10			<10				<10									
Md:	Baltimore			<10				<10			<10				<10							<10			14					
Mass:	Boston			<10				<10			<10				14		11					<10			<10					
Mich:	Detroit			<10				10			<10				13			10				<10								
	Grand Rapids	<10						<10			10				<10			18				<10								
Minn:	Minneapolis			<10				20			30				10			<10				<10			<10					
Miss:	Jackson							20			15				<10			20				<10			<10					
Mo:	Kansas City			40				30			50				40			20				10			<10					
	St. Louis						90			50				30			40				20			<10						
Mont:	Helena			<10				<10			<10				<10			20				<10			<10					
Nebr:	Omaha			70				20			<10				60			30												
Nev:	Las Vegas			40					20					<10				20					<10		<10					
N.H.:	Manchester	<10						<10			<10			<10			<10				<10			<10						
N.J.:	Trenton			<10					<10		<10				<10		<10					<10		<10						
N. Mex:	Albuquerque		<10				30				30			20				20			<10			<10						
N.Y.:	Buffalo			<10				<10			<10				<10			<10				<10			<10					
	New York			<10			<10			<10				<10			<10				<10			<10						
	Syracuse	14		<10				<10			<10				<10			<10				<10			<10					
N.C.:	Charlotte		37				27				17			17				<10			<10				17					
N. Dak:	Minot		<10				<10				20			<10			<10				<10			<10						
Ohio:	Cincinnati			19				<10		<10					11			<10				<10			<10					
	Cleveland	<10		<10				<10			14				<10			<10				<10			<10					
Okla:	Oklahoma City		97				57				25			25				14			17				13					
Ore:	Portland			<10				20			<10				<10			<10					<10			<10					
Pa:	Philadelphia			15				<10			<10											<10			<10					
	Pittsburgh	19		<10				<10			<10					<10		<10				<10		<10						
P.R.:	San Juan			2f				19			<10				<10			<10				<10			<10					
R.I.:	Providence			<10				<10			<10				<10			<10				<10			<10					
S.C.:	Charleston							19			<10				<10			<10				15			<10					
S. Dak:	Rapid City			<10			30				40				40			20				<10			50					
Tenn:	Chattanooga			22				11			<10				<10			<10				<10			<10					
	Memphis		61				29		15					12			<10				<10			<10						
Tex:	Austin			48				12			<10							11												
	Dallas		46				26		20					<10			<10				<10			<10						
Utah:	Salt Lake City			<10				20						<10				20				<10								
Vt.:	Burlington		<10				<10			<10					<10			12				<10								
Va:	Norfolk			18				12			<10				<10			11				<10			<10					
Wash:	Seattle			<10				<10			10				<10			<10				10			<10					
	Spokane			<10				20							<10			20				<10			<10					
W. Va:	Charleston			15				<10			<10				<10			<10				<10		<10						
Wis:	Milwaukee			13				13			13				<10			<10				<10			<10					
Wyo:	Laramie			<10				<10			<10				<10			<10				<10			<10					

through June 1966. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

In anticipation of an intrusion of iodine–131 levels to pasteurized milk, as a result of recently reported nuclear detonations (*2*), the sampling and analysis frequency for this radionuclide was increased to twice weekly as of May 16. The individual sample results for June 1966 are presented in table 4.

2. Canadian Milk Network June 1966[1]

Radiation Protection Division
Department of National Health and Welfare, Ottawa, Canada

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (*3*).

The June 1966 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine–131 concentrations were below minimum detectable levels.

[1] Prepared from July 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 5. Stable elements and radionuclides in Canadian whole milk, June 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.13	1.5	12	20.8	33
Edmonton	1.08	1.6	6	17.8	44
Ft. William	1.11	1.6	12	26.1	69
Fredericton	1.10	1.6	2	28.1	58
Halifax	1.12	1.5	7	24.8	41
Montreal	1.11	1.6	6	16.5	40
Ottawa	1.12	1.6	8	12.1	34
Quebec	1.11	1.5	8	22.9	67
Regina	1.07	1.5	4	17.1	10
St. John's, Nfld	1.10	1.6	7	35.5	108
Saskatoon	1.11	1.6	2	21.1	22
Sault Ste. Marie	1.09	1.6	8	24.6	69
Toronto	1.13	1.5	5	11.0	33
Vancouver	1.14	1.6	4	22.1	91
Windsor	1.15	1.5	10	9.7	30
Winnipeg	1.10	1.6	28	15.3	47
Average	1.11	1.6	8	20.3	50

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program June 1966

Pan American Health Organization and U.S. Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

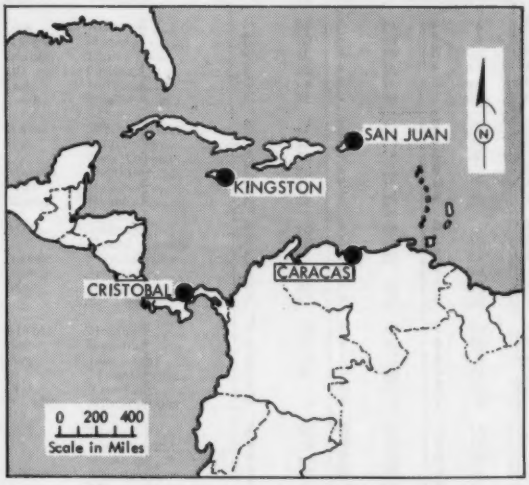

Figure 4. Pan American Milk Sampling Program stations

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data* (*4*).

Table 6 presents stable calcium and potassium, strontium–90, strontium–89, and cesium–137 monthly average concentrations for June 1966. During this period, iodine–131 and barium–140 concentrations were below detectable levels.

Table 6. PAHO stable elements and radionuclide concentrations in milk, June 1966

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone:					
Cristobal	NA	1.5	5	4	20
Jamaica:					
Kingston	NS	NS	NS	NS	NS
Mandeville	NS	NS	NS	NS	NS
Montego Bay	1.11	1.6	90	12	300
Puerto Rico:					
San Juan	NA	1.5	<5	8	25
Venesuela:					
Caracas	NS	NS	NS	NS	NS

NA, no analysis reported.
NS, no sample collected.

4. Annual Average Radionuclide Concentrations in Pasteurized Milk for the 12-Month Periods Ending September 1965 Through June 1966

Division of Radiological Health Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) program are reported on a monthly basis in *Radiological Health Data and Reports*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*5*) and permissible concentrations in selected environmental media (*6*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake-dose and dose-biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be

used in conjunction with the references cited above to approximate the radiation dose to a specific population group from a specific radionuclide. Tables 7 to 10 present annual averages of radionuclide concentrations in milk sampled by the PMN.[2] Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*7,8*).

[2] Annual averages for barium–140 at each station were <2 pCi/liter.

Table 7. Moving annual average strontium-89 concentrations in milk for 12-month periods starting October 1964 and ending February 1966 [a]

Sampling location		Average strontium-89 concentrations, pCi/liter					
		Oct 1964–Sept 1965	Nov 1964–Oct 1965	Dec 1964–Nov 1965	Jan 1965–Dec 1965	Feb 1965–Jan 1966	Mar 1965–Feb 1966
Ala:	Montgomery	3	3	3	3	3	3
Alaska:	Palmer	3	3	3	3	3	3
Ariz:	Phoenix	3	3	3	3	3	3
Ark:	Little Rock	5	4	4	4	4	4
Calif:	Sacramento	3	3	3	3	3	3
	San Francisco	3	3	3	3	3	3
C. Z:	Cristobal	3	3	3	3	3	3
Colo:	Denver	3	3	3	3	3	3
Conn:	Hartford	3	3	3	3	3	3
Del:	Wilmington	3	3	3	3	3	3
D. C:	Washington	3	3	3	3	3	3
Fla:	Tampa	3	3	3	3	3	3
Ga:	Atlanta	3	3	3	3	3	3
Hawaii:	Honolulu	3	3	3	3	3	3
Idaho:	Idaho Falls	3	3	3	3	3	3
Ill:	Chicago	3	3	3	3	3	3
Ind:	Indianapolis	3	3	3	3	3	3
Iowa:	Des Moines	4	4	4	4	4	4
Kans:	Wichita	3	3	3	3	3	3
Ky:	Louisville	4	4	4	4	4	4
La:	New Orleans	5	5	4	3	4	4
Maine:	Portland	3	3	3	3	3	3
Md:	Baltimore	3	3	3	3	3	3
Mass:	Boston	3	3	3	3	3	3
Mich:	Detroit	3	3	3	3	3	3
	Grand Rapids	3	3	3	3	3	3
Minn:	Minneapolis	7	6	6	6	6	6
Miss:	Jackson	3	3	3	3	3	3
Mo:	Kansas City	5	5	5	5	5	5
	St. Louis	4	4	4	4	4	4
Mont:	Helena	3	3	3	3	3	3
Nebr:	Omaha	3	3	3	3	3	3
Nev:	Las Vegas	3	3	3	3	3	3
N. H:	Manchester	3	3	3	3	3	3
N. J:	Trenton	3	3	3	3	3	3
N. Mex:	Albuquerque	2	2	2	2	2	2
N. Y:	Buffalo	3	3	3	3	3	3
	New York	3	3	3	3	3	3
	Syracuse	3	3	3	3	3	3
N. C:	Charlotte	3	3	3	3	3	3
N. Dak:	Minot	6	6	6	6	6	6
Ohio:	Cincinnati	3	3	3	3	3	3
	Cleveland	4	4	4	4	4	4
Okla:	Oklahoma City	5	5	4	4	4	4
Ore:	Portland	3	3	3	3	3	3
Pa:	Philadelphia	3	3	3	3	3	3
	Pittsburgh	4	4	4	4	4	4
P. R:	San Juan	3	3	3	3	3	3
R. I:	Providence	3	3	3	3	3	3
S. C:	Charleston	3	3	3	3	3	3
S. Dak:	Rapid City	7	7	7	7	7	7
Tenn:	Chattanooga	4	4	4	3	3	3
	Memphis	4	4	4	4	4	4
Tex:	Austin	3	3	3	3	3	3
	Dallas	3	3	3	3	3	3
Utah:	Salt Lake City	3	3	3	3	3	3
Vt:	Burlington	3	3	3	3	3	3
Va:	Norfolk	4	3	3	3	3	3
Wash:	Seattle	3	3	3	3	3	3
	Spokane	3	3	3	3	3	3
W. Va:	Charleston	4	4	4	4	4	4
Wis:	Milwaukee	3	3	3	3	3	3
Wyo:	Laramie	3	3	3	3	3	3
Network average		3	3	3	3	3	3

[a] Strontium-89 analyses were discontinued in March 1966 except for a minimum of 10 percent of selected samples. Consequently, strontium-89 12-month averages will no longer be reported.

Table 8. Moving annual average strontium-90 concentrations in milk for 12-month periods starting October 1964 and ending June 1966

Sampling location		Average strontium-90 concentrations, pCi/liter									
		Oct 1964–Sept 1965	Nov 1964–Oct 1965	Dec 1964–Nov 1965	Jan 1965–Dec 1965	Feb 1965–Jan 1966	Mar 1965–Feb 1966	Apr 1965–Mar 1966	May 1965–Apr 1966	June 1965–May 1966	July 1965–June 1966
Ala:	Montgomery	18	17	17	16	16	15	14	14	13	13
Alaska:	Palmer	18	17	17	17	16	16	16	15	15	15
Ariz:	Phoenix	5	5	5	5	5	4	4	5	4	4
Ark:	Little Rock	34	33	33	32	31	31	30	29	29	29
Calif:	Sacramento	6	6	6	6	6	6	6	6	6	6
	San Francisco	8	7	7	7	6	7	6	6	6	6
C.Z:	Cristobal	4	4	4	4	4	4	4	4	4	4
Colo:	Denver	17	16	16	16	15	15	14	13	13	12
Conn:	Hartford	16	15	14	14	14	13	13	13	12	12
Del:	Wilmington	18	18	18	17	17	17	16	16	16	15
D.C:	Washington	16	16	15	15	15	14	14	14	13	13
Fla:	Tampa	13	13	13	13	12	12	12	12	12	12
Ga:	Atlanta	25	24	24	24	23	22	22	21	20	20
Hawaii:	Honolulu	10	9	9	8	8	7	7	6	6	6
Idaho:	Idaho Falls	19	19	18	17	17	16	16	15	15	14
Ill:	Chicago	15	15	14	14	13	13	12	12	12	11
Ind:	Indianapolis	16	16	15	15	15	14	14	13	13	12
Iowa:	Des Moines	21	20	20	19	18	18	17	16	16	15
Kans:	Wichita	17	17	16	16	16	15	15	14	14	14
Ky:	Louisville	22	21	21	20	20	19	19	18	18	18
La:	New Orleans	39	38	38	37	36	35	33	32	31	31
Maine:	Portland	22	21	21	20	19	19	18	18	17	17
Md:	Baltimore	18	17	17	17	17	16	16	16	15	15
Mass:	Boston	22	21	21	20	19	19	18	17	16	16
Mich:	Detroit	15	14	14	13	13	13	12	12	11	11
	Grand Rapids	18	17	17	16	16	16	15	15	15	15
Minn:	Minneapolis	25	25	25	25	24	24	23	23	22	22
Miss:	Jackson	31	30	30	29	28	27	27	25	25	25
Mo:	Kansas City	21	20	20	19	19	19	18	17	17	17
	St. Louis	17	17	18	17	17	17	17	17	17	17
Mont:	Helena	18	18	18	18	17	17	17	16	16	15
Nebr:	Omaha	19	19	19	18	18	18	18	17	17	16
Nev:	Las Vegas	7	7	6	6	6	6	6	6	6	6
N.H:	Manchester	23	23	23	22	22	21	21	20	19	19
N.J:	Trenton	15	15	14	14	14	14	13	13	13	12
N. Mex:	Albuquerque	9	9	9	9	8	7	7	7	6	6
N.Y:	Buffalo	15	15	14	14	13	13	12	12	11	11
	New York	19	19	18	18	17	17	16	16	15	15
	Syracuse	15	15	15	14	14	13	13	13	12	12
N.C:	Charlotte	28	27	27	26	25	25	24	23	22	22
N. Dak:	Minot	45	44	44	42	40	39	37	35	33	32
Ohio:	Cincinnati	16	16	16	15	15	14	14	14	13	13
	Cleveland	17	16	16	16	15	15	15	14	13	13
Okla:	Oklahoma City	18	18	17	17	17	16	15	14	14	14
Ore:	Portland	20	19	18	17	17	16	15	15	14	13
Pa:	Philadelphia	16	16	16	15	15	14	14	14	13	13
	Pittsburgh	23	23	22	21	21	20	20	19	19	18
P.R:	San Juan	11	11	11	10	10	10	9	9	9	9
R.I:	Providence	18	18	18	17	17	16	16	15	15	14
S.C:	Charleston	27	27	27	26	26	25	25	24	23	23
S. Dak:	Rapid City	27	27	26	26	25	24	24	23	23	21
Tenn:	Chattanooga	30	29	28	27	26	25	25	24	23	22
	Memphis	24	23	23	22	22	21	20	19	19	18
Tex:	Austin	7	7	7	7	7	6	6	6	6	6
	Dallas	16	16	16	16	15	15	14	14	14	14
Utah:	Salt Lake City	20	20	19	19	18	16	16	15	13	12
Vt:	Burlington	20	19	19	18	18	17	17	16	16	15
Va:	Norfolk	15	14	14	13	13	12	12	11	11	11
Wash:	Seattle	22	22	21	21	20	19	19	18	17	17
	Spokane	23	23	22	22	21	20	19	18	17	17
W. Va:	Charleston	18	18	18	18	17	17	17	17	16	16
Wis:	Milwaukee	14	14	14	13	13	13	12	12	11	11
Wyo:	Laramie	15	15	15	15	15	15	15	15	15	14
Network average		18.7	18.3	18.0	17.5	17.0	16.5	16.0	15.5	15.0	14.7

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*9*) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–

90 to calcium in milk in a particular locality by 1.5."[3] Thus, a rough index of the total dietary intake of strontium–90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 g of calcium per liter in PMN samples and 1.0 g daily intake of calcium.

In the case of iodine–131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk.

[3] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of non-milk products whose contamination reflects temporal and local distribution patterns (*10*).

Table 9. Moving annual average iodine-131 concentrations in milk for 12-month periods starting October 1964 and ending June 1966

Sampling location		Average iodine-131 concentrations, pCi/liter									
		Oct 1964–Sept 1965	Nov 1964–Oct 1965	Dec 1964–Nov 1965	Jan 1965–Dec 1965	Feb 1965–Jan 1966	Mar 1965–Feb 1966	Apr 1965–Mar 1966	May 1965–Apr 1966	June 1965–May 1966	July 1965–June 1966
Ala:	Montgomery	0	0	0	0	0	0	0	0	2	2
Alaska:	Palmer	1	1	1	1	1	1	1	1	2	2
Ariz:	Phoenix	0	0	0	0	0	0	0	0	0	0
Ark:	Little Rock	2	2	2	2	2	2	2	2	8	9
Calif:	Sacramento	1	1	1	1	1	1	1	1	0	0
	San Francisco	0	0	0	0	0	0	0	0	0	0
C.Z:	Cristobal	0	0	0	0	0	0	0	0	0	0
Colo:	Denver	2	2	2	2	2	2	2	2	2	1
Conn:	Hartford	0	0	0	0	0	0	0	0	0	0
Del:	Wilmington	2	2	1	1	1	1	1	1	2	1
D.C:	Washington	2	2	2	2	2	2	2	2	2	0
Fla:	Tampa	0	0	0	0	0	0	0	0	1	2
Ga:	Atlanta	1	1	1	1	1	1	1	1	2	2
Hawaii:	Honolulu	0	0	0	0	0	0	0	0	0	0
Idaho:	Idaho Falls	2	2	2	2	2	2	2	2	2	1
Ill:	Chicago	2	2	2	2	2	2	2	2	2	0
Ind:	Indianapolis	4	4	3	3	3	3	3	3	7	6
Iowa:	Des Moines	6	6	6	6	6	6	6	6	5	3
Kans:	Wichita	2	2	2	2	2	2	2	2	4	5
Ky:	Louisville	2	2	2	2	2	2	2	2	4	2
La:	New Orleans	2	2	2	2	2	2	2	2	2	2
Maine:	Portland	2	2	1	1	1	1	1	1	1	0
Md:	Baltimore	2	2	2	2	2	2	2	2	2	0
Mass:	Boston	0	0	0	0	0	0	0	0	0	0
Mich:	Detroit	3	2	2	2	2	2	2	2	2	1
	Grand Rapids	2	2	2	2	2	2	2	2	2	0
Minn:	Minneapolis	6	6	6	6	6	6	6	5	5	2
Miss:	Jackson	1	1	1	1	1	1	1	1	2	2
Mo:	Kansas City	8	8	8	8	8	8	8	8	9	7
	St. Louis	5	5	5	5	5	5	5	5	9	9
Mont:	Helena	3	2	2	2	2	2	2	2	0	0
Nebr:	Omaha	4	4	4	4	4	4	4	4	4	2
Nev:	Las Vegas	2	2	2	2	2	2	2	2	2	2
N.H:	Manchester	1	1	0	0	0	0	0	0	0	0
N.J:	Trenton	1	1	0	0	0	0	0	0	0	0
N. Mex:	Albuquerque	2	1	1	1	1	1	1	1	1	2
N.Y:	Buffalo	0	0	0	0	0	0	0	0	0	0
	New York	2	2	1	1	1	1	1	1	1	0
	Syracuse	1	1	1	1	1	1	1	1	1	0
N.C:	Charlotte	1	1	1	1	1	1	1	1	3	4
N. Dak:	Minot	2	2	2	2	2	2	2	2	2	0
Ohio:	Cincinnati	2	2	2	2	2	2	2	2	2	1
	Cleveland	2	2	2	2	2	2	2	2	2	0
Okla:	Oklahoma City	2	2	2	2	2	2	2	2	6	6
Ore:	Portland	1	1	1	1	1	1	1	1	1	1
Pa:	Philadelphia	0	0	0	0	0	0	0	0	0	0
	Pittsburgh	2	2	2	2	2	2	2	2	2	0
P.R:	San Juan	1	1	1	1	1	1	1	1	2	2
R.I:	Providence	0	0	0	0	0	0	0	0	0	0
S.C:	Charleston	1	1	1	1	1	1	1	1	3	4
S. Dak:	Rapid City	4	4	4	4	4	4	4	4	4	3
Tenn:	Chattanooga	1	1	1	2	2	2	2	2	3	3
	Memphis	2	2	2	2	2	2	2	2	4	4
Tex:	Austin	2	2	2	2	2	2	2	2	3	3
	Dallas	1	1	1	1	1	1	1	1	3	4
Utah:	Salt Lake City	2	2	2	2	2	2	2	2	2	1
Vt:	Burlington	2	1	0	0	0	0	0	0	0	0
Va:	Norfolk	3	3	3	3	3	3	3	3	2	1
Wash:	Seattle	1	1	1	1	1	1	1	1	1	1
	Spokane	0	0	0	0	0	0	0	0	0	1
W. Va:	Charleston	2	2	2	2	2	2	2	2	2	1
Wis:	Milwaukee	3	3	2	2	2	2	2	2	2	0
Wyo:	Laramie	2	2	2	2	2	2	2	2	2	0
Network average		2	2	2	2	2	2	2	2	2	2

With most other foods, normal processing and distribution allow time for the radioactive decay of this short-lived nuclide to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

Table 10. Moving annual average cesium-137 concentrations in milk for 12-month periods starting October 1964 and ending June 1966 [a]

Sampling location		Average cesium-137 concentrations, pCi/liter									
		Oct 1964–Sept 1965	Nov 1964–Oct 1965	Dec 1964–Nov 1965	Jan 1965–Dec 1965	Feb 1965–Jan 1966	Mar 1965–Feb 1966	Apr 1965–Mar 1966	May 1965–Apr 1966	June 1965–May 1966	July 1965 June 1966
Ala:	Montgomery	49	46	44	42	39	37	34	31	29	27
Alaska:	Palmer	64	61	58	57	55	54	52	49	47	46
Ariz:	Phoenix	22	21	21	19	19	17	16	16	15	14
Ark:	Little Rock	63	59	56	54	52	50	47	44	42	40
Calif:	Sacramento	29	28	28	27	25	23	22	21	19	18
	San Francisco	29	29	27	27	25	24	22	20	19	19
C.Z.:	Cristobal	39	37	35	34	33	32	30	29	28	27
Colo:	Denver	62	57	54	52	49	45	40	36	32	29
Conn:	Hartford	76	72	68	64	60	56	51	48	44	42
Del:	Wilmington	64	61	58	55	51	48	45	42	40	37
D.C:	Washington	48	45	44	43	40	38	35	33	31	29
Fla:	Tampa	181	174	168	162	156	153	148	144	138	135
Ga:	Atlanta	79	75	71	68	64	60	56	51	47	46
Hawaii:	Honolulu	59	56	54	51	48	45	43	40	37	36
Idaho:	Idaho Falls	84	82	79	75	68	63	58	53	48	44
Ill:	Chicago	68	65	62	59	54	50	46	42	38	36
Ind:	Indianapolis	54	51	48	44	41	37	34	31	29	28
Iowa:	Des Moines	50	48	45	42	40	36	35	32	29	28
Kans:	Wichita	42	40	40	37	34	31	28	26	24	22
Ky:	Louisville	44	41	39	37	34	31	28	25	24	23
La:	New Orleans	75	71	68	66	63	61	56	52	49	47
Maine:	Portland	124	117	110	104	97	92	87	82	76	74
Md:	Baltimore	54	52	50	48	45	42	39	35	32	31
Mass:	Boston	117	112	107	101	93	88	81	74	68	66
Mich:	Detroit	67	63	60	56	52	48	43	40	35	33
	Grand Rapids	76	72	68	65	61	58	53	50	47	44
Minn:	Minneapolis	77	74	72	67	63	60	55	51	46	43
Miss:	Jackson	52	49	46	44	41	39	35	33	32	31
Mo:	Kansas City	42	41	39	37	34	31	28	26	24	23
	St. Louis	41	39	37	34	32	30	29	27	25	25
Mont:	Helena	83	79	76	73	70	66	63	59	56	53
Nebr:	Omaha	50	48	47	45	43	40	38	36	35	33
Nev:	Las Vegas	37	36	34	31	29	28	26	24	22	22
N.H:	Manchester	140	133	125	118	109	103	97	92	83	80
N.J:	Trenton	65	62	58	54	51	47	44	40	37	35
N. Mex:	Albuquerque	36	34	31	29	27	24	22	19	17	17
N.Y:	Buffalo	84	80	76	72	66	60	55	49	43	41
	New York	85	80	76	71	65	61	56	51	46	45
	Syracuse	75	71	67	62	56	52	48	43	40	38
N.C:	Charlotte	59	56	52	50	46	44	41	38	35	33
N. Dak:	Minot	103	97	92	86	78	72	66	60	53	46
Ohio:	Cincinnati	51	48	45	42	38	34	31	28	27	25
	Cleveland	69	65	62	57	52	48	43	38	35	33
Okla:	Oklahoma City	42	40	38	36	33	31	29	26	24	22
Ore:	Portland	82	78	74	69	66	59	54	49	45	41
Pa:	Philadelphia	60	57	54	51	48	45	41	38	35	33
	Pittsburgh	84	80	76	72	66	62	57	52	48	46
P.R:	San Juan	48	46	44	42	39	37	35	33	31	29
R.I:	Providence	90	86	81	77	72	68	64	59	53	51
S.C:	Charleston	87	85	82	78	74	72	68	63	57	55
S. Dak:	Rapid City	101	96	91	84	76	68	61	55	50	46
Tenn:	Chattanooga	59	55	52	50	46	43	39	37	34	32
	Memphis	39	37	35	33	31	29	26	24	22	20
Tex:	Austin	26	25	24	23	22	20	18	17	16	15
	Dallas	37	36	35	33	31	29	27	24	23	22
Utah:	Salt Lake City	99	94	91	85	77	70	64	57	48	43
Vt:	Burlington	98	94	89	84	78	73	68	63	57	55
Va:	Norfolk	55	52	49	46	43	41	38	36	32	30
Wash:	Seattle	90	85	81	77	73	69	65	62	57	53
	Spokane	85	80	76	71	64	60	56	52	47	44
W. Va:	Charleston	39	37	36	34	32	30	28	25	23	23
Wis:	Milwaukee	78	74	70	66	61	57	52	48	43	41
Wyo:	Laramie	63	62	59	57	54	51	48	44	42	39
Network average		67	64	61	58	54	50	47	43	40	38

[a] Annual averages for barium-140 at each station were <3 pCi/liter.

The relative contribution of milk to the total dietary intake of cesium–137 is not well defined and depends principally on the amount of freshly deposited cesium–137 on products used for human and animal consumption, and on the progress of cesium–137 through the food chain.

The data in tables 7 to 10 are calculated as follows: results from all samples collected each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of 12 consecutive months are averaged to obtain the annual average.[4] To obtain the annual average daily intake (pCi/day) of radionuclides from milk, the annual average concentration values (pCi/liter) in tables 7 to 10 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average obtained by updating the previous 12-month average by 1 month shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

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[4] Beginning with the October 1963 data, iodine–131 values of <10 pCi/liter are considered to be zero for averaging purposes; previously, 5 pCi/liter was used for calculating the averages.

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STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs supported by functional radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

State milk network	Period reported	Last presented
California	January–March 1966	September 1966
Connecticut	January–March 1966	August 1966
Indiana	January–March 1966	August 1966
Michigan	October–December and annual summary 1965	May 1966
Minnesota	January–March 1966	August 1966
New York	July–December and annual summary 1965	May 1966
Oregon	January–March 1966	September 1966
Pennsylvania	January–March 1966	August 1966
Washington	January–March 1966	September 1966

1. Colorado Milk Network January 1965—June 1966

Occupational and Radiological Health Division
Colorado State Department of Public Health

The Radiological Health Division of the Colorado State Department of Public Health initiated radiological analysis of milk in January 1962. Initially, the Denver City and County Health Department collected a weekly composite milk sample from the major producers in the Denver area for the State, as it had for the Public Health Service since March 1960.

In August 1962, the State expanded its program to include the routine sampling of raw milk from the four major milk producing areas supplying the State: northeastern, southeastern, and western Colorado, and eastern Utah. The five Colorado milk sampling areas are shown in figure 1.

Recent analyses have been made on samples coming into the State Health Department primarily for other purposes. Frequent sampling has been resumed only in response to some nuclear test announcements. At this present time, samples from each area may be either local or imported milk and may be either raw or pasteurized.

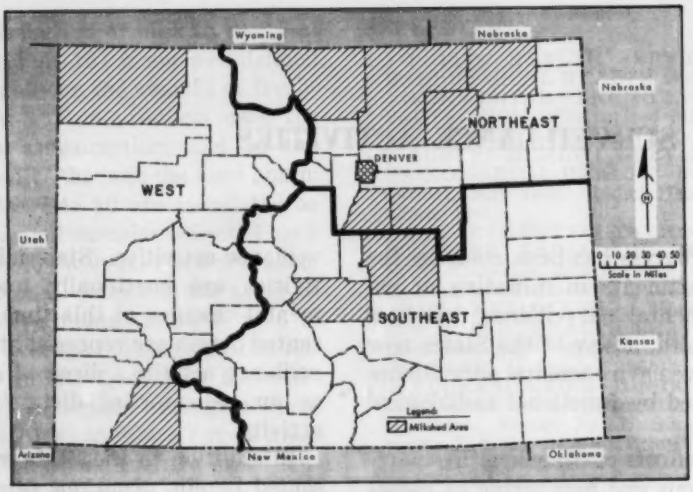

Figure 1. Colorado milk sampling areas

Table 1. Potassium and radionuclides in Colorado milk, May to December 1965 and May–June 1966

Date	Denver			Northeastern			Southeastern			Western			Eastern Utah		
	Potassium (g/liter)	Iodine-131 (pCi/liter)	Cesium-137 (pCi/liter)	Potassium (g/liter)	Iodine-131 (pCi/liter)	Cesium-137 (pCi/liter)	Potassium (g/liter)	Iodine-131 (pCi/liter)	Cesium-137 (pCi/liter)	Potassium (g/liter)	Iodine-131 (pCi/liter)	Cesium-137 (pCi/liter)	Potassium (g/liter)	Iodine-131 (gCi/liter)	Cesium-137 (gCi/liter)
1965															
May	1.9	<10	45	1.6	<10	15	1.7	<10	27						
	1.8	<10	43	1.7	<10	25									
	1.9	<10	70	1.6	<10	44									
	1.6	<10	50												
June	1.4	<10	42	1.2	<10	45									
	1.3	26	49	1.2	<10	42									
	1.5	<20	55	1.4	<10	43									
	1.7	<10	56	1.0	<10	36									
July	1.5	<10	37	1.3	<10	30									
	1.7	<10	11	1.6	<10	12									
August	1.7	<10	14	1.3	<10	30	1.7	<10	54				1.6	<10	42
	1.6	<10	13	1.7	<10	41									
	1.5	<10	60												
	1.7	<10	21												
September	1.4	<10	27	1.5	<10	31	1.2	<10	44	1.4	<20	<20	1.8	<20	20
	1.7	<10	20				1.6	<10	17						
	1.6	20	39												
	1.7	<10	11												
October	1.7	<10	5										1.5	<10	34
	1.7	<10	17												
	2.0	<20	12												
	1.7	<10	12												
November							1.5	<10	20						
December	1.7	<10	21												
1966															
May	1.3	<10	17	1.4	<10	19	1.5	<10	19	1.2	<10	<10	1.6	<10	<10
	1.3	<10	12	1.5	<10	15	1.4	<10	14	1.8	<10	26	1.6	<10	41
	1.5	<10	11	1.5	<10	10	1.4	<10	<10						
	1.7	<10	12				1.4	<10	<10						
	1.7	<10	18				1.6	<10	<10						
	1.4	<10	25				1.9	<10	34						
	1.6	<10	16				1.5	<10	23						
	1.5	<10	16				1.4	<10	18						
	1.5	<10	15				1.2	<10	11						
	1.5	<10	16				1.2	<10	14						
	1.6	<10	<10				1.5	<10	12						
	1.4	<10	19												
June							1.8	<10	19	1.6	<20	13			
										1.8	<10	11			

Analyses are conducted for potassium, iodine–131, cesium–137, and barium–140, using gamma spectroscopy. The gamma measurement system used for milk analysis has been modified since results were last reported in 1965 (*1*). Currently a 4- by 5-inch NaI crystal shielded by a modified safe is used.

Minimum detectable amounts at the 95-percent confidence level are as follows: iodine–131 (10 pCi/liter); barium-lanthanum–140 (15 pCi/liter); cesium–137 (10 pCi/liter); and potassium (0.2 g/liter).

Table 1 gives stable potassium, iodine–131, and cesium–137 concentrations in milk determined on samples collected from May 1965 through June 1966. During this period, barium-lanthanum–140 was not detected. Results for January through April 1965 and January through April 1966 are not available.

Previous coverage in *Radiological Health Data:*

Period	Issue
July–September 1964	February 1965
October–December 1964 and summary for 1962–1964	April 1965

2. Florida Milk Network April–June 1966

Division of Radiological and Occupational Health
Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine–131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium–89, strontium–90, and cesium–137, in addition to iodine–131. Raw milk samples are received from the six areas shown in figure 2. Monthly samples are taken from randomly selected farms in the areas represented. A regional State Board of Health laboratory is located in each of the six areas referred to in this report. Each laboratory prepares a monthly composite milk sample for its region by combining samples from 10 percent of the dairy farms selected at random. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. In the interest of maintaining an active standby capability, samples are now collected and analyzed for iodine–131 on a monthly basis using the resin cartridge technique. Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are characterized by differences in dairying practices related to the gradual transition from small farms in the west Florida region, where locally grown feeds are used, to larger farms in the southern areas, where different types of grass and predominately purchased feeds are used.

Figure 2. Florida milk sampling areas

Strontium–89 and strontium–90 are determined by the ion exchange method developed by Porter *et al.*(*2*). Iodine–131 and cesium–137 are determined by gamma-scintillation spectrometry (*3*).

Radionuclide concentration levels for April through June 1966 are presented in tables 2 and 3. Strontium–89 analyses have been discontinued due to extremely low levels during 1965. During this period, iodine–131 concentrations were below the minimum detectable level of 30 pCi/liter.

Table 2. Strontium-90 in Florida raw milk, April–June 1966

Month	Concentration, pCi/liter						
	West Florida	North Florida	Northeast Florida	Central Florida	Tampa Florida	Southeast Florida	Average
April	28.4	19.4	14.5	15.0	8.2	7.5	15.5
May	29.0	21.0	8.3	NS	9.3	8.5	15.2
June	36.8	20.6	8.3	14.9	11.5	10.2	17.0
Average	31.4	20.5	10.4	14.9	9.7	8.9	15.9

NS, no sample.

Table 3. Cesium-137 in Florida raw milk, April–June 1966

Month	Concentration, pCi/liter						
	West Florida	North Florida	Northeast Florida	Central Florida	Tampa Florida	Southeast Florida	Average
April	21	55	144	109	130	84	90
May	27	55	120	100	143	80	89
June	40	22	129	154	107	115	94
Average	29	44	131	124	128	93	91

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual summary 1964	November 1965
January–June 1965	January 1966
July–December 1965	April 1966
January–March 1966	July 1966

3. Oklahoma Milk Network April–June 1966

Oklahoma State Department of Health[1]

On March 15, 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine–131 in the milk produced in the State of Oklahoma. On March 7, 1966, analysis for cesium–137 was added to the program.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 3. Of the 10 milksheds in the State of Oklahoma, 5 were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) on the basis of their size and location. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled. This overlap assists in locating small areas of production where the concentration of radioactivity might be abnormally high.

The sampling stations are located in the laboratory of a major milk-processing plant in each milkshed. While the milkshed for a particular processing plant may not coincide exactly with that shown in figure 3, the coincidence is satisfactory for surveillance purposes.

At the present time, samples are collected on Monday morning, and the analyses are completed by Wednesday afternoon. However, if iodine–131 or cesium–137 levels detected are such that diversion of the milk or other precautionary methods need to be taken, the analytical method and equipment can be employed to sample each truck arriving at the processing plant. Under these conditions, only about 4 hours would be needed to complete the analysis. This greatly reduced lag time for analysis would permit rapid decisions on the fate of each truckload of raw milk.

The analytical procedure used is a modification of those published by Boni (*4*) and Porter (*5*) and consists of passing 1 quart of milk through a two-section cartridge containing Dowex 1X8, 50–100 mesh in one section and potassium cobalt ferrocyanide (KCFC) in the other. Iodine–131 is adsorbed on the Dowex 1X8 and cesium–137 on the KCFC.

[1] Acknowledgment is accorded to the staff of the Radiological Health Section under the direction of Mr. Dale McHard, head, and Mr. Robert Craig, assistant engineer.

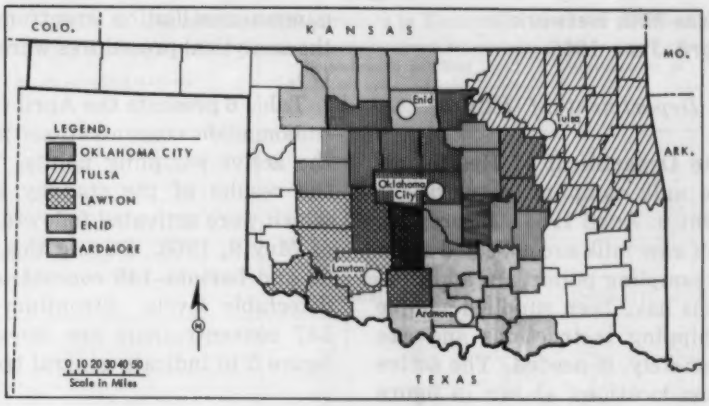

Figure 3. Oklahoma milkshed sampling areas

In practice, the cartridges are prepared in the laboratory and mailed to the sampling stations where pasteurized milk is passed through them. The cartridges are returned to the laboratory where the sections are separated and the ion exchange media counted for 100 minutes in a 2-by 2-inch sodium iodide well crystal attached to a multichannel analyzer.

The limits of detection, defined as the 3σ error of background, are 3.3 pCi/liter for iodine–131 and 9.7 pCi/liter for cesium–137.

Table 4 gives the concentration of iodine–131 in Oklahoma milk for the period April 4 through June 27, 1966. Table 5 gives the concentration of cesium–137 for the period March 7 through June 27, 1966.

Table 4. Concentration of iodine-131 in Oklahoma milk April–June 1966

Date 1966	Sampling location, concentrations in pCi/liter					
	Oklahoma City	Enid	Tulsa	Lawton	Ardmore	Oklahoma City *
April 1	ND	ND	ND	ND	ND	NS
18	5	ND	ND	ND	ND	NS
May 2	ND	ND	ND	ND	ND	NS
16	ND	ND	ND	ND	ND	NS
20	NS	NS	NS	NS	NS	8
23	39	49	208	7	21	NS
24	NS	NS	NS	NS	NS	103
31	83	70	49	103	26	81
June 2	NS	NS	NS	NS	NS	118
6	NS	36	42	21	23	61
10	NS	NS	NS	NS	NS	18
13	NS	17	20	13	11	23
17	NS	NS	NS	NS	NS	15
20	14	12	13	6	8	11
27	ND	4	6	ND	ND	ND

* Sample split with PHS Pasteurized Milk Network sample from Oklahoma City station.
ND, non-detectable, concentrations less than 3.3 pCi/liter.
NS, no sample received.

Table 5. Concentration of cesium-137 in Oklahoma milk March–June 1966

Date 1966	Sampling location, concentrations in pCi/liter					
	Oklahoma City	Enid	Tulsa	Lawton	Ardmore	Oklahoma City *
March 7	NS	NS	34	20	23	NS
14	21	NS	NS	NS	NS	NS
April 1	21	13	62	15	22	NS
18	24	15	25	33	19	NS
May 2	24	19	22	20	23	NS
16	18	33	41	11	NS	NS
20	NS	NS	NS	NS	NS	35
23	20	22	45	29	21	NS
24	NS	NS	NS	NS	NS	34
31	29	19	35	19	18	27
June 2	NS	NS	NS	NS	NS	26
6	NS	29	27	18	ND	22
10	NS	NS	NS	NS	NS	26
13	NS	25	35	23	22	25
17	NS	NS	NS	NS	NS	30
20	20	20	29	13	38	21
27	21	20	29	20	15	15

* Sample split with PHS Pasteurized Milk Network sample from Oklahoma City station.
NS, no sample received.
ND, non-detectable, concentrations less than 9.7 pCi/liter.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
March–July 1965	October 1965
August–December 1965	April 1966
January–March 1966	July 1966

4. Texas Milk Network April–June 1966

Texas State Department of Health[2]

The Texas State Department of Health initiated a statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of six active sampling points. In addition, six standby stations have been supplied sample containers and shipping instructions and can be activated immediately, if needed. The active and standby station locations, shown in figure 4, were chosen to give maximum geographical and population coverage.

Samples are routinely analyzed for strontium–89 and strontium–90 by a chemical separation technique employing ion exchange columns (*6*).

Potassium–40, iodine–131, cesium–137, and barium–140, concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (*7*).

Table 6 presents the April through June 1966 radionuclide concentrations in Texas milk for the active sampling points. Table 7 presents the results of the standby sampling stations which were activated following the Chinese test of May 9, 1966. During this time, strontium–89 and barium–140 concentrations were below detectable levels. Strontium–90 and cesium–137 concentrations are shown graphically in figure 5 to indicate general trends.

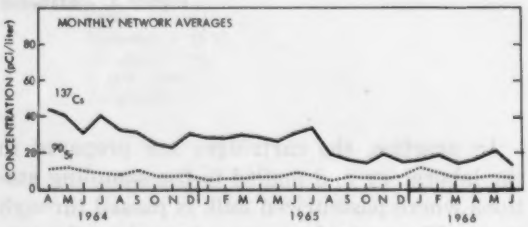

Figure 5. Radionuclide concentrations in Texas milk 1964–June 1966

Figure 4. Texas milk sampling stations

[2] Acknowledgment is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

Table 6. Radionuclide concentrations in Texas milk, April–June 1966

Active sampling stations	Potassium-40, pCi/liter			Strontium-90, pCi/liter		
	April	May	June	April	May	June
Austin	NS	1,280	1,190	NS	5	5
Dallas	NS	1,240	1,250	NS	7	5
El Paso	1,290	1,340	1,280	3	4	5
Harlingen	1,320	1,250	1,300	3	5	4
Houston	1,250	1,280	1,260	12	12	11
Lubbock	1,100	1,280	1,240	5	6	7
Average	1,240	1,280	1,250	5.8	6.5	6.1
	Iodine-131, pCi/liter			Cesium-137, pCi/liter		
Austin	NS	ND	10	NS	20	13
Dallas	NS	40	10	NS	25	15
El Paso	ND	5	7	10	15	13
Harlingen	ND	2	5	5	12	13
Houston	ND	10	5	40	35	25
Lubbock	ND	43	8	15	17	16
Average	ND	16.7	7.5	17.5	20.7	16.0

NS, no sample collected.
ND, below detectable levels.

Table 7. Radionuclide concentrations in Texas milk, May–June 1966

Standby sampling stations	Number of samples		Potassium-40 (pCi/liter)		Strontium-90 (pCi/liter)		Iodine-131 (pCi/liter)		Barium-140 (pCi/liter)		Cesium-137 (pCi/liter)	
	May	June	May	June	May	June	May	June	May	June	May	June
Amarillo	2	4	1,270	1,200	7	5	25	20	ND	ND	20	14
Corpus Christi	2	6	1,240	1,230	4	4	15	13	ND	ND	20	15
Galveston	2	5	1,220	1,200	9	12	ND	10	ND	ND	38	35
Lubbock	3	4	1,280	1,240	6	7	45	10	ND	ND	17	16
Midland	1	3	1,260	1,300	3	3	10	13	ND	ND	10	20
Texarkana	2	2	1,290	1,250	15	18	110	ND	15	ND	40	35
Wichita Falls	1	5	1,300	1,210	12	9	140	15	15	ND	25	15

ND, below detectable level.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
1964 Summary	June 1965
January–March 1965	October 1965
April–December 1965	April 1966
January–March 1966	July 1966

REFERENCES

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(7) TEXAS STATE DEPARTMENT OF HEALTH. Texas milk network, January–March 1965. Radiol Health Data 6:541–542 (October 1965).

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are listed below:

Program	Period reported	Last presented
Tri-City Diet, HASL	November 1965–January 1966	September 1966
Teenage Diet, FDA	February–November 1965	August 1966
California Diet	September–December 1965	September 1966
Connecticut Standard Diet	January–June 1965	February 1966

1. Radionuclides in Institutional Total Diet Samples January–March 1966

Division of Radiological Health
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Total Diet Sampling Program in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program was designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicted that the number of institutions sampled could be selectively reduced. As of July 1965, 21 institutions, distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily intake of teenage girls and that of children from 9 to 12 years of age were comparable, while teenage boys consumed 20 per-

Figure 1. Institutional diet sampling locations as of July 1965

cent more food per day (*1,2*). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. The monthly sample supplied by each institution represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks), obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada; the Southeastern Radiological Health Laboratory, Montgomery, Alabama; or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts. A detailed description of sampling and analytical procedures was presented elsewhere (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from January through March 1966, for children 9 to 12 years of age. The stable elements calcium and potassium are reported in g/kg of diet, and the radionuclide concentrations of strontium–89, strontium–90, cesium–137, and radium–226 are expresed as pCi/kg of diet.

Dietary intakes, presented in table 2, were obtained by multiplying the food consumption rate in kg/day by the concentration values given in table 1. The reported radionuclide concentrations of these samples are collected for radioactive decay to the midpoint of the sample collection period, where applicable.

Certain of the radionuclide concentration results have been reported as being "less than" a specified value. For the purpose of obtaining dietary intakes, "less than" 5 pCi/kg of strontium–89 was interpreted as 2.5 pCi/kg, and "less than" 10 pCi/kg values for iodine–131 and barium–140 were interpreted as zero.

The average food consumption rate during this period was 1.90 kg/day and was the same as the network average of 1.90 kg/day observed from 1961 through 1964 (*4*).

While strontium–89 dietary intake remained below detectable levels, the strontium–90 dietary intake during this period remained fairly constant at approximately 22 pCi/day. These results fall within Range II as defined by the Federal Radiation Council (*5*), indicating that quantitative surveillance and routine control are recommended.

Table 1. Stable element and radionuclide concentrations in institutional total diets of children (9–12 years of age) January–March 1966 [a]

Location of institution		Month 1966	Stable elements, g/kg of diet		Radionuclide concentrations, pCi/kg of diet			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska:	Palmer	Jan	0.7	1.3	<5	13	45	0.5
		Feb	1.0	0.9	<5	27	55	0.6
		Mar	0.5	1.2	<5	15	40	0.4
Ariz:	Phoenix	Jan	0.7	1.1	<5	10	25	0.4
		Feb	0.7	1.0	<5	14	35	0.2
		Mar [b]	0.6	1.1	<5	11	25	0.4
Ark:	Little Rock	Jan	0.7	1.4	<5	12	20	0.7
		Feb	0.7	1.5	<5	20	30	1.1
		Mar	0.7	1.6	<5	14	20	1.2
Calif:	Los Angeles	Jan	0.7	1.2	<5	7	20	0.3
		Feb	0.9	1.7	<5	8	20	0.4
		Mar	1.0	1.2	<5	16	20	1.0
Colo:	Denver	Jan	0.8	1.5	<5	15	30	0.2
		Feb	0.7	1.2	<5	10	20	0.4
		Mar	0.7	0.9	<5	12	10	0.5
Del:	Wilmington	Jan	0.7	1.6	<5	11	35	0.9
		Feb	0.8	1.6	<5	10	40	1.1
		Mar	0.7	1.7	<5	11	40	0.7
Fla:	Tampa	Jan	0.7	1.4	<5	9	70	1.3
		Feb	0.9	1.6	<5	14	45	1.4
		Mar	0.7	1.5	<5	10	60	1.5
Hawaii:	Honolulu	Jan	0.5	1.3	<5	5	35	0.2
		Feb	0.5	1.2	<5	5	25	0.4
		Mar	0.5	1.4	<5	5	25	0.5
Idaho:	Idaho Falls	Jan	0.8	1.3	<5	9	45	0.7
		Feb	0.8	1.5	<5	16	35	0.8
		Mar	0.7	1.4	<5	11	40	0.5
Ill:	Chicago	Jan	0.8	1.5	<5	7	45	0.6
		Feb	0.7	1.4	<5	9	45	0.5
		Mar	0.8	1.5	<5	9	40	0.4
Ky:	Louisville	Jan	0.8	1.9	<5	12	25	1.2
		Feb	1.0	1.5	<5	16	25	2.1
		Mar	0.9	1.7	<5	14	30	1.3
La:	New Orleans	Jan	0.7	1.8	<5	19	35	0.4
		Feb	0.8	1.6	<5	16	40	1.4
		Mar	0.8	1.4	<5	17	30	1.0
Mass:	Boston	Jan	0.5	1.4	<5	8	45	0.7
		Feb	0.5	1.4	<5	7	25	0.5
		Mar	0.6	1.4	<5	7	35	0.6
Mo:	St Louis	Jan	0.8	1.7	<5	10	40	0.9
		Feb	0.8	1.7	<5	11	30	0.5
		Mar	0.6	1.5	<5	11	35	0.8
Ohio:	Cleveland	Jan	0.6	1.8	<5	9	35	0.8
		Feb	0.6	1.7	<5	9	55	0.7
		Mar	0.6	1.7	<5	11	40	0.3
Pa:	Pittsburgh	Jan	0.7	1.4	<5	12	45	0.7
		Feb	0.8	1.6	<5	10	30	1.2
		Mar	0.6	1.2	<5	10	30	0.5
S.C:	Charleston	Jan	0.8	1.6	<5	20	45	1.4
		Feb	0.8	1.5	<5	13	40	1.5
		Mar	0.7	1.5	<5	15	35	1.4
S. Dak:	Sioux Falls	Jan	0.8	1.7	<5	14	70	0.7
		Feb	0.8	1.4	<5	13	40	0.8
		Mar	0.8	1.7	<5	14	60	0.6
Tex:	Austin	Jan	0.6	1.3	<5	8	20	1.8
		Feb	0.6	1.4	<5	7	15	1.5
		Mar	0.6	1.4	<5	7	25	1.8
Vt:	Burlington	Jan	0.7	1.7	<5	12	65	0.8
		Feb	0.7	1.5	<5	13	40	0.7
		Mar	0.7	1.5	<5	11	45	0.8
Wash:	Seattle	Jan	0.7	1.5	<5	10	50	0.3
		Feb	0.8	1.6	<5	17	70	0.4
		Mar	0.7	1.4	<5	12	40	0.4
Institutional average		Jan	0.7	1.5	<5	11	40	0.7
		Feb	0.8	1.5	<5	13	35	10.9
		Mar	0.7	1.4	<5	12	35	0.8

[a] During the first quarter of 1966, both iodine-131 and barium-140 concentrations were below detectable levels.
[b] The food sample for this month did not contain the milk portion of the diet.
NA, no analysis.

Cesium–137 intakes averaged 67 pCi/day during this period. Both barium–140 and iodine–131 concentrations were below detectable levels.

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(3) DIVISION OF RADIOLOGICAL HEALTH, PUBLIC HEALTH SERVICE. Radionuclides in institutional total diet samples, April–June 1965. Radiol Health Data Rep 7:92–98. (February 1966).

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Table 2. Intake of stable elements and radionuclides in institutional total diet for children (9–12 years of age) January–March 1966

Location of institution		Month 1966	Total weight (kg/day)	Stable elements intakes, g/day		Radionuclide intakes, pCi/day			
				Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska:	Palmer	Jan	1.68	1.2	2.2	5	22	75	0.8
		Feb	1.93	1.9	1.7	5	52	105	1.2
		Mar	1.89	0.9	2.3	5	28	75	0.8
Ariz:	Phoenix	Jan	2.16	1.5	2.4	5	22	55	0.9
		Feb	1.98	1.4	2.0	5	28	70	0.4
		Mar	[a] 1.67	1.0	1.8	5	18	40	0.7
Ark:	Little Rock	Jan	1.87	1.3	2.6	5	22	35	1.3
		Feb	1.87	1.3	2.8	5	37	55	2.1
		Mar	1.61	1.1	2.6	5	23	30	1.9
Calif:	Los Angeles	Jan	2.06	1.4	2.5	5	14	40	0.6
		Feb	2.13	1.9	3.6	5	17	45	0.9
		Mar	1.91	1.9	2.3	5	31	40	1.9
Colo:	Denver	Jan	2.26	1.8	3.4	5	34	70	0.5
		Feb	2.19	1.5	2.6	5	22	45	0.9
		Mar	2.82	2.0	2.5	5	34	30	1.4
Del:	Wilmington	Jan	2.05	1.4	3.3	5	22	70	1.8
		Feb	1.80	1.4	2.9	5	18	70	2.0
		Mar	2.14	1.5	3.6	5	24	85	1.5
Fla:	Tampa	Jan	2.13	1.5	3.0	5	19	150	2.8
		Feb	2.04	1.8	3.3	5	29	90	2.9
		Mar	2.03	1.4	3.0	5	20	120	3.0
Hawaii:	Honolulu	Jan	1.98	1.0	2.6	5	10	70	0.4
		Feb	2.03	1.0	2.4	5	10	50	0.8
		Mar	2.13	1.1	3.0	5	11	55	1.1
Idaho:	Idaho Falls	Jan [b]	1.92	1.5	2.5	5	17	85	1.3
		Feb [b]	1.82	1.5	2.7	5	29	65	1.5
		Mar [b]	1.90	1.3	2.7	5	21	75	1.0
Ill:	Chicago	Jan [b]	1.72	1.4	2.6	5	12	75	1.0
		Feb	1.46	1.0	2.0	5	13	65	0.7
		Mar [b]	1.69	1.4	2.5	5	15	70	0.7
Ky:	Louisville	Jan	1.33	1.1	2.5	5	16	35	1.6
		Feb	1.38	1.4	2.1	5	22	35	2.9
		Mar	1.22	1.1	2.1	5	17	35	1.6
La:	New Orleans	Jan	1.73	1.2	3.1	5	33	60	0.7
		Feb [c]	2.08	1.7	3.3	5	33	85	2.9
		Mar [c]	2.14	1.7	3.0	5	36	65	2.1
Mass:	Boston	Jan	2.37	1.2	3.3	5	19	105	1.7
		Feb	2.39	1.2	3.3	5	17	60	1.2
		Mar	2.51	1.5	3.5	5	18	90	1.5
Mo:	St. Louis	Jan	2.59	2.1	4.4	5	26	105	2.3
		Feb	2.57	2.1	4.4	5	28	75	1.3
		Mar	2.57	1.5	3.9	5	28	90	2.1
Ohio:	Cleveland	Jan	1.57	0.9	2.8	5	14	55	1.3
		Feb	1.77	1.1	3.0	5	16	95	1.2
		Mar	1.67	1.0	2.8	5	18	65	0.5
Pa:	Pittsburgh	Jan [b]	2.24	1.6	3.1	5	27	100	1.6
		Feb [b]	2.36	1.9	3.8	5	24	70	2.8
		Mar [b]	2.33	1.4	2.8	5	23	70	1.2
S.C:	Charleston	Jan	1.43	1.1	2.3	5	29	65	2.0
		Feb	1.74	1.4	2.6	5	33	70	2.6
		Mar [d]	1.78	1.2	2.7	5	26	60	2.5
S. Dak:	Sioux Falls	Jan	1.75	1.4	3.0	5	24	120	1.2
		Feb	1.91	1.5	2.7	5	25	75	1.5
		Mar	1.82	1.5	3.1	5	25	110	1.1
Tex:	Austin	Jan	1.59	1.0	2.1	5	13	30	2.9
		Feb	1.72	1.0	2.4	5	12	25	2.6
		Mar	1.69	1.0	2.4	5	12	40	3.0
Vt:	Burlington	Jan	1.31	0.9	2.2	5	16	85	1.0
		Feb	1.36	1.0	2.0	5	18	55	1.0
		Mar	1.21	0.8	1.8	5	13	55	1.0
Wash:	Seattle	Jan [b]	1.73	1.2	2.6	5	17	85	0.5
		Feb [b]	1.53	1.2	2.4	5	26	105	0.6
		Mar [b]	1.30	0.9	1.8	5	16	50	0.5
Institutional average		Jan	1.87	1.3	2.8	5	21	70	1.4
		Feb	1.90	1.4	2.7	5	23	65	1.5
		Mar	1.93	1.3	2.7	5	21	65	1.5

[a] The food sample for this month did not contain the milk portion of the diet.
[b] Data for this month were not used in computing the average for all institutions since food samples were collected from two or more children over 12 years of age.
[c] Data for this month were not used in computing the average for all institutions since food samples were collected from two or more children under 9 years of age.
[d] Data for this month were not used in computing the average for all institutions since food samples were collected from children whose ages were not given.

(5) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–March 1964	October 1964
April–June 1964	January 1965
July–September 1964	April 1965
October–December and annual averages 1964	July 1965
January–March 1965	October 1965
April–June 1965	February 1966
July–September 1965	May 1966
October–December and annual averages 1965	July 1966

Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross alpha and gross beta radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below:

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium–90, respectively.

Program	Period reported	Last presented
Radiostrontium in Tap Water, HASL	May and July–November 1965	June 1966
California Water Sampling Program	January–June 1965	March 1966
Colorado River Basin Sampling Network	1962–1964	November 1965
Coast Guard Water Sampling Program	1964	November 1965
Drinking Water Analysis Program	1962	October 1965
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963–June 1964	March 1965
Minnesota Surface Water Sampling Program	July–December 1965	July 1966
New York Surface Water Sampling Program	June–December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Washington Surface Water Sampling Program	July 1964–June 1965	May 1966

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GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, APRIL 1966

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the Federal Water Pollution Control Administration on December 31, 1965. Table 1 presents the current preliminary results of the alpha and beta analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure

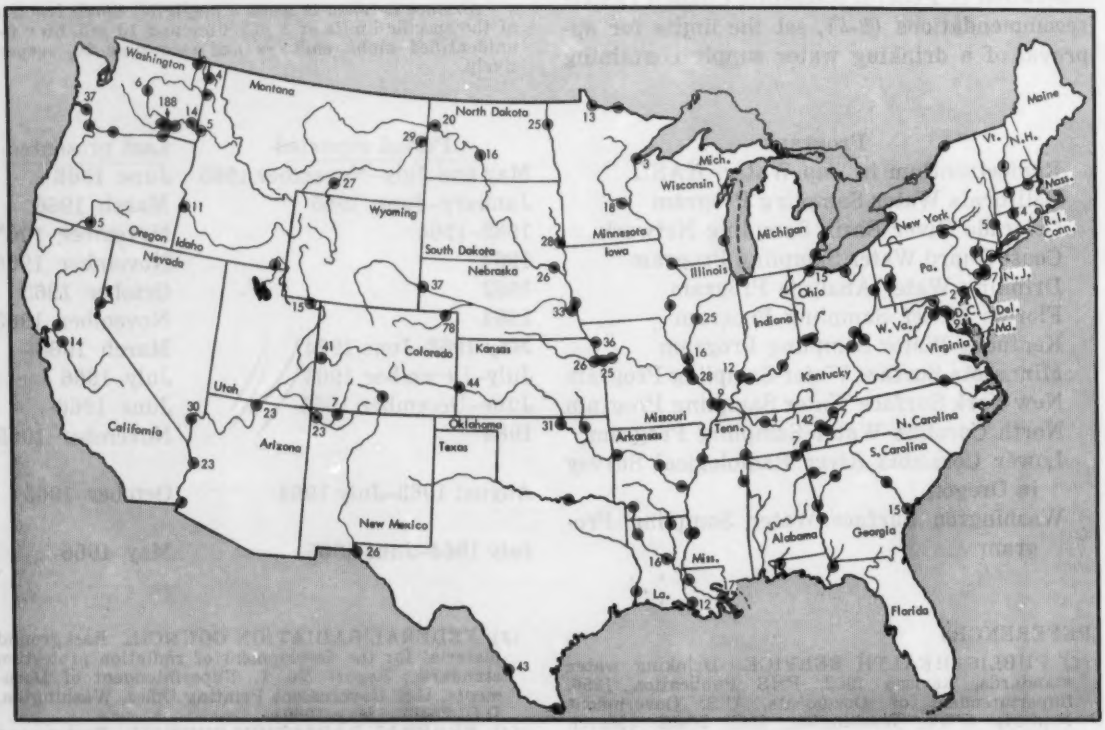

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, April 1966

Table 1. Radioactivity in raw surface waters, April 1966

Stations	Average beta activity (pCi/liter)			Average alpha activity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	1	6	7	0	2	2
Arkansas River:						
Coolidge, Kans.	3	41	44	<1	17	17
Ponca City, Okla.	6	25	31	1	7	8
Atchafalaya River:						
Morgan City, La.	3	9	12	1	1	2
Big Horn River:						
Hardin, Mont.	5	22	27	2	8	10
Big Sioux River:						
Sioux Falls, S. Dak.	6	22	28	1	1	2
Chena River:						
Fairbanks, Alaska	<1	2	2	0	<1	<1
Clearwater River:						
Lewiston, Idaho	2	3	5	0	0	0
Clinch River:						
Clinton, Tenn.	3	4	7	0	0	0
Kingston, Tenn.[a]	7	135	142	0	1	1
Colorado River:						
Loma, Colo.	30	11	41	8	3	11
Page, Ariz.	1	22	23	0	6	6
Boulder City, Nev.	1	29	30	0	10	10
Parker Dam, Calif.-Ariz.	0	23	23	0	8	8
Columbia River:						
Wenatchee, Wash.	1	5	6	0	1	1
Pasco, Wash.[a]	25	163	188	0	1	1
Clatskanie, Ore.	10	27	37	0	<1	<1
Connecticut River:						
Enfield Dam, Conn.	1	3	4	0	0	0
Cumberland River:						
Cheatham Lock, Tenn.	0	4	4	0	0	0
Delaware River:						
Philadelphia, Pa.	4	3	7	1	0	1
Great Lakes:						
Duluth, Minn.	0	3	3	0	0	0
Green River:						
Dutch John, Utah	<1	15	15	0	3	3
Hudson River:						
Poughkeepsie, N. Y.	1	4	5	0	0	0
Illinois River:						
Peoria, Ill.	11	14	25	2	3	5
Grafton, Ill.	5	11	16	1	1	2
Kansas River:						
DeSoto, Kans.	7	19	26	2	3	5
Klamath River:						
Keno, Ore.	0	5	5	0	0	0
Maumee River:						
Toledo, Ohio	4	11	15	1	2	3
Mississippi River:						
St. Paul, Minn.	2	16	18	0	2	2
E. St. Louis, Ill.	17	11	28	5	1	6
New Orleans, La.	7	10	17	2	1	3
Missouri River:						
Williston, N. Dak.	6	14	20	2	2	4
Bismarck, N. Dak.	1	15	16	0	2	2
Yankton, S. Dak.	2	24	26	0	3	3
St. Joseph, Mo.	11	25	36	2	6	8
Kansas City, Kans.	1	24	25	0	4	4
North Platte River:						
Henry, Nebr.	2	35	37	<1	20	20
Ohio River:						
Cairo, Ill.	2	7	9	0	0	0
Pend Oreille River:						
Albeni Falls Dam, Idaho	<1	4	4	0	<1	<1
Platte River:						
Plattsmouth, Nebr.	9	24	33	2	8	10
Potomac River:						
Washington, D. C.	5	4	9	0	0	0
Rainy River:						
Baudette, Minn.	2	11	13	<1	0	<1
Red River, North:						
Grand Forks, N. Dak.	6	19	25	1	1	2
Red River, South:						
Alexandria, La.	2	14	16	0	1	1
Rio Grande:						
El Paso, Tex.	11	15	26	3	4	7
Laredo, Tex.	30	13	43	5	4	9
San Joaquin River:						
Vernalis, Calif.	1	13	14	0	6	6
San Juan River:						
Shiprock, N. Mex.	15	8	23	3	2	5
Savannah River:						
Port Wentworth, Ga.[a]	3	12	15	0	0	0
Snake River:						
Payette, Idaho	1	10	11	0	3	3
Wawawai, Wash.	10	4	14	0	0	0
South Platte River:						
Julesburg, Colo.	6	72	78	1	58	59
Susquehanna River:						
Conowingo, Md.	0	2	2	0	0	0
Tennessee River:						
Chattanooga, Tenn.	1	6	7	0	0	0
Wabash River:						
New Harmony, Ind.	4	8	12	1	1	2
Yellowstone River:						
Sidney, Mont.	18	11	29	6	2	8
Maximum	30	163	188	6	58	59
Minimum	0	2	2	0	0	0

[a] Gross beta activity at this station may not be directly comparable to gross beta activity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides common to all stations.

1 indicates the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations are published in annual compliations (*1-6*) or are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are

significantly high, comment will be made.

During March and April, the following stations showed alpha radioactivity in excess of 15 pCi/liter on dissolved solids:

North Platte River: Henry, Nebraska
Arkansas River: Coolidge, Kansas
South Platte River: Julesburg, Colorado

Ponca City, Oklahoma, on the Arkansas River, dropped below 15 pCi/liter on alpha radioactivity on dissolved solids.

During April, Pasco, Washington, on the Columbia River, showed a beta radioactivity in slight excess of 150 pCi/liter on dissolved solids. At Kingston, Tennessee, on the Clinch River, the average beta radioactivity for the month was less than 150 pCi/liter; however, the sample collected on April 18 yielded 328 pCi/liter.

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(1) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data. PHS publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(2) *Ibid.*, 1959 Edition.
(3) *Ibid.*, 1960 Edition.
(4) *Ibid.*, 1961 Edition.
(5) *Ibid.*, 1962 Edition.
(6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data. PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

On intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to the programs presented in this issue, the following program was previously covered in *Radiological Health Data and Reports*:

Network	Period	Issue
HASL Fallout Network	July–December 1965	September 1966

1. Radiation Surveillance Network June 1966

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples for laboratory analysis. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analytical procedures was presented in the December 1965 issue of *Radiological Health Data.*

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during June 1966. Time profiles of gross beta in air for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on 327 air samples. Fresh fission products were identified in 165 air samples during June 1966, in addition to traces of longer-lived fission products from earlier testing.

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta activity in surface air and precipitation, June 1966

Station location		Number of samples		Air surveillance			Last profile in *RHD&R*	Precipitation	
				Gross beta activity, pCi/m³					
		Air	Pptn	Maximum	Minimum	Average [a]		Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	30	3	0.74	0.15	0.30	Feb 66	71	<20
Alaska:	Adak	30		0.13	<0.10	<0.10	June 66	[c]	
	Anchorage	13	4	0.45	<0.10	<0.16	Mar 66	14	<3
	Attu Island	[b]					July 66	[c]	
	Fairbanks	[b]					Apr 66	[c]	
	Juneau	20	5	0.14	<0.10	<0.10	July 65	32	<6
	Kodiak	6		<0.10	<0.10	<0.10	May 66	[c]	
	Nome	[b]					Sept 66	[c]	
	Point Barrow	30		0.15	<0.10	<0.10	Aug 66	[c]	
	St. Paul Island	29		<0.10	<0.10	<0.10	Jan 66	[c]	
Ariz:	Phoenix	26		1.30	0.24	0.67	July 65	[c]	
Ark:	Little Rock	12		1.08	0.13	0.35	Mar 66	[c]	
Calif:	Berkeley	26	1	0.33	<0.10	<0.12	May 66	2	1
	Los Angeles	21		0.28	<0.10	<0.16	Sept 66	[c]	
C.Z:	Ancon	16		<0.10	<0.10	<0.10	May 66	[c]	
Colo:	Denver	29	7	1.98	<0.10	0.62	May 66	39	<11
Conn:	Hartford	30	9	0.45	<0.10	<0.22	Apr 66	40	<10
Del:	Dover	22		0.56	<0.10	0.24	Feb 66		
D.C.:	Washington	28	5	0.60	<0.10	<0.27	Aug 66	53	<12
Fla:	Jacksonville	30	8	0.69	0.15	0.31	Mar 66	147	<30
	Miami	24	15	1.30	<0.10	0.40	Apr 66	262	<53
Ga:	Atlanta	[b]	5				Oct 66	65	<13
Guam:	Agana	30		0.54	<0.10	<0.23	Feb 66	[c]	
Hawaii:	Honolulu	29		0.52	<0.10	0.26	July 66	[c]	
Idaho:	Boise	29	2	0.48	<0.10	<0.24	July 66	5	5
Ill:	Springfield	29	4	0.53	<0.10	0.27	Aug 66	17	<6
Ind:	Indianapolis	28	4	0.64	<0.10	0.30	Oct 66	37	<10
Iowa:	Iowa City	29	8	0.48	<0.10	<0.23	May 66	171	<46
Kans:	Topeka	30	10	0.59	<0.10	0.28	Mar 66	169	<46
Ky:	Frankfort	27	4	0.79	0.11	0.35	Aug 66	19	<4
La:	New Orleans	30	6	0.74	0.15	0.35	Aug 66	55	<11
Maine:	Augusta	29	9	0.48	<0.10	<0.21	Sept 66	87	<20
	Presque Isle	25	6	0.39	<0.10	<0.17	May 66	31	<6
Md:	Baltimore	22	7	0.60	<0.10	0.35	Apr 66	38	<8
	Rockville Lab	15		0.47	<0.10	<0.27	July 66	[c]	
Mass:	Lawrence	30	8	0.60	<0.10	<0.24	Feb 66	51	<14
	Winchester	28	8	0.39	<0.10	<0.18	June 66	68	<15
Mich:	Lansing	29	7	0.53	<0.10	<0.23	July 66	58	<18
Minn:	Minneapolis	21	10	0.42	<0.10	<0.20	Feb 66	103	<35
Miss:	Jackson	29	2	0.67	0.13	0.29	Sept 66	22	<10
Mo:	Jefferson City	29	5	0.49	<0.10	0.27	Oct 66	57	<18
Mont:	Helena	30	7	0.46	<0.10	<0.25	June 66	27	<9
Nebr:	Lincoln	26	8	1.66	<0.10	<0.34	Jan 66	64	<17
Nev:	Las Vegas	26		1.10	0.28	0.57	Apr 66	[c]	
N.H:	Concord	22		0.73	<0.10	<0.25	Aug 66	[c]	
N.J:	Trenton	30	3	0.46	<0.10	<0.24	Sept 66	4	<1
N. Mex:	Santa Fe	25	8	1.59	0.14	0.68	June 66	34	<10
N.Y:	Albany	21	9	0.83	<0.10	<0.24	Oct 66	57	<12
	Buffalo	30		0.47	<0.10	<0.21	May 66	[c]	
	New York	30		0.37	<0.10	<0.19	June 66	[c]	
N.C:	Gastonia	30	4	0.70	0.16	0.34	May 66	97	<19
N. Dak:	Bismarck	26	9	0.76	<0.10	<0.22	Aug 66	106	<26
Ohio:	Cincinnati	19		0.27	<0.10	<0.18	Feb 66	[c]	
	Columbus	29	5	1.06	0.12	0.53	Sept 66	20	<4
	Painesville	27	5	0.65	<0.10	<0.27	Apr 66	55	<13
Okla:	Oklahoma City	28	1	0.91	<0.10	0.32	July 66	22	<4
	Ponca City	23	5	0.33	<0.10	<0.15	Apr 66	84	<19
Ore:	Portland	30	7	0.61	<0.10	<0.17	Jan 66	23	<5
Pa:	Harrisburg	29		0.43	<0.10	<0.21	Oct 66	[c]	
P.R:	San Juan	25	5	2.34	0.13	0.56	Sept 66	146	<29
R.I:	Providence	27	7	0.34	<0.10	<0.17	July 66	55	<11
S.C:	Columbia	26	5	0.77	<0.10	0.32	June 66	175	<35
S. Dak:	Pierre	30	1	1.65	<0.10	0.32	July 65	3	4
Tenn:	Nashville	29	3	0.64	<0.10	0.27	July 66	29	15
Tex:	Austin	30	5	0.87	0.18	0.39	Feb 66	15	<4
	El Paso	30	6	1.85	<0.10	0.60	Aug 66	47	<10
Utah:	Salt Lake City	28	2	1.51	0.17	0.60	Sept 66	1	2
Vt:	Barre	28	10	0.74	<0.10	<0.25	Mar 66	76	<15
Va:	Richmond	30	8	0.44	<0.10	<0.24	Mar 66	82	<17
Wash:	Seattle	29	8	0.20	<0.10	<0.10	Mar 66	18	<4
	Spokane	30	2	0.46	<0.10	<0.19	Feb 66	4	2
W. Va:	Charleston	28	3	0.71	<0.10	0.29	June 66	8	<2
Wis:	Madison	30	7	0.51	<0.10	<0.19	Mar 66	87	<28
Wyo:	Cheyenne	30	4	2.34	<0.10	0.61	Apr 66	51	<39
Network summary		1,851	309	2.34	<0.10	<0.28		59	<15

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If more than 10 percent of the samples contain <0.10 pCi/m³, a less-than sign is placed before the average.
[b] Indicates no report received.
[c] Indicates no precipitation sample collected.

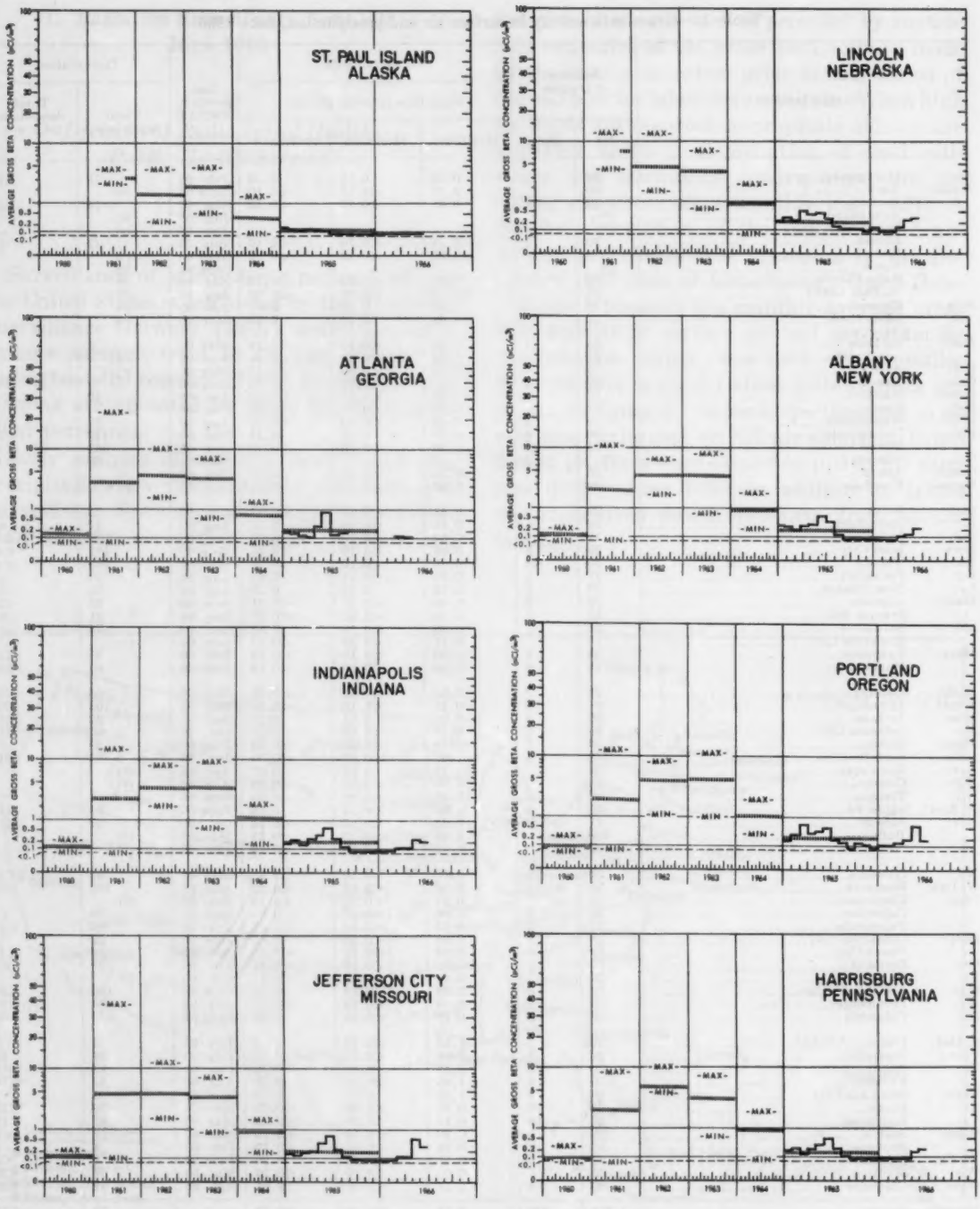

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1960—June 1966

2. Canadian Air and Precipitation Monitoring Program, June 1966[1]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data.*

[1] Prepared from information and data in the July 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for June 1966 are presented in table 2.

Table 2. Canadian gross beta activity in surface air and precipitation, June 1966

Station	Number of samples	Air surveillance activity, pCi/m³			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.7	0.1	0.2	60	4.8
Coral Harbour	30	0.2	0.0	0.0	44	1.3
Edmonton	30	0.3	0.0	0.1	163	7.9
Ft. Churchill	30	0.2	0.0	0.1	123	4.1
Ft. William	30	0.4	0.0	0.1	150	5.7
Fredericton	30	0.4	0.0	0.2	139	7.2
Goose Bay	23	0.3	0.0	0.1	31	2.9
Halifax	30	0.4	0.0	0.2	62	3.7
Inuvik	30	0.4	0.0	0.1	184	2.2
Montreal	16	0.4	0.1	0.2	55	4.2
Moosonee	29	0.5	0.0	0.1	85	8.6
Ottawa	30	0.8	0.0	0.2	145	8.1
Quebec	30	0.6	0.0	0.2	152	11.4
Regina	30	0.8	0.0	0.2	83	8.9
Resolute	29	0.1	0.0	0.0	37	0.2
St. John's, Nfld	29	0.5	0.0	0.1	39	3.8
Saskatoon	30	0.4	0.0	0.2	102	13.9
Sault Ste. Marie	30	0.5	0.0	0.2	216	12.2
Toronto	30	0.9	0.1	0.3	151	8.3
Vancouver	30	0.4	0.0	0.1	75	3.9
Whitehorse	30	0.6	0.0	0.2	80	3.3
Windsor	29	0.7	0.1	0.3	129	12.6
Winnipeg	30	0.6	0.0	0.2	160	5.7
Yellowknife	30	0.3	0.0	0.2	97	3.1
Network summary		0.9	0.0	0.2	107	6.2

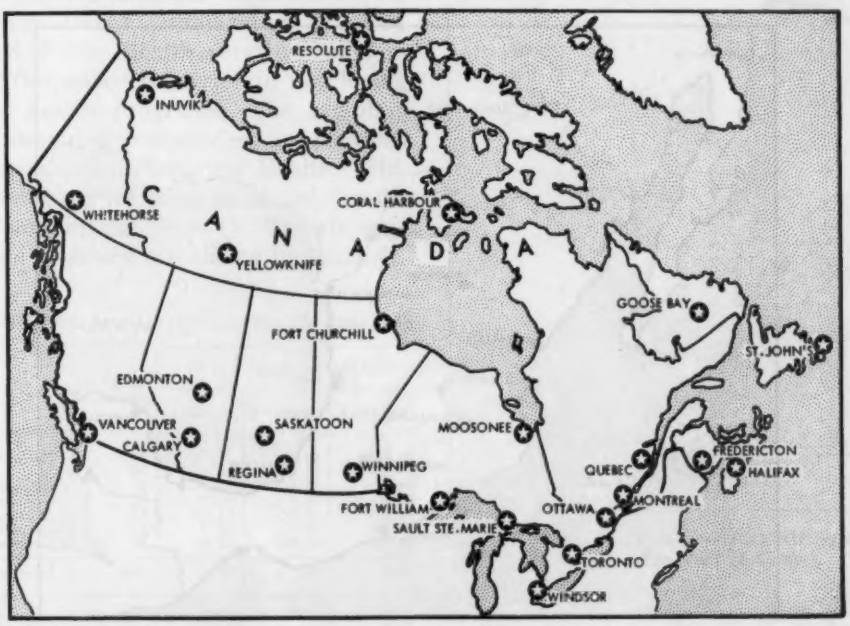

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program March and April 1966

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México City. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance network. In 1966, the Division of Radiological Protection was restructured and its name changed to General Direction of Radiological Security (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRS operate the station at Mexico City, while the other four stations are manned by members of the Centro de Previsión del Golfo de Mexico, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- x 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via air mail to the Sección de Radioactividad Ambiental, CNEN, in Mexico City for assay of gross beta activity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data is not extrapolated to the time of collection. Statistically, it has been found that a minimum of eight samples per month was needed to get a reliable average of activity in each station (*8*).

The maximum, minimum, and average fission product beta concentrations in surface air during March and April 1966 are presented in tables 3 and 4.

Figure 4. Mexican air sampling station locations

Table 3. Mexican gross beta activity of airborne particulates March 1966

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	NS			
Ciudad Juárez	10	0.4	0.1	0.3
Chihuahua	10	0.5	0.1	0.3
Ensenada	11	0.4	0.1	0.2
Guadalajara	3	0.2	0.1	
Guaymas	7	0.5	0.1	0.2
La Paz	11	0.7	0.1	0.3
Matamoros	9	0.6	0.1	0.3
Mazatlán	10	0.5	0.1	0.3
Mérida	12	0.6	0.1	0.3
México, D.F.	18	0.7	0.1	0.2
Nuevo Laredo	10	0.4	0.1	0.3
San Luis Potosí	6	0.2	0.1	0.1
Tampico	6	0.2	0.1	0.1
Torreón	15	0.4	0.1	0.3
Tuxtla Gutiérrez [a]				
Veracruz	13	0.5	0.1	0.3

[a] Sampling discontinued February 1966 at Tuxtla Gutierrez.
NS, no sample collected: station temporarily shutdown.

Table 4. Mexican gross beta activity of airborne particulate April 1966

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	4	0.1	0.1	0.1
Ciudad Juárez	15	0.5	0.1	0.2
Chihuahua	6	0.5	0.1	0.2
Ensenada	2	0.1	0.1	0.1
Guadalajara	NS			
Guaymas	1	0.5	0.5	0.5
La Paz	14	0.4	0.1	0.2
Matamoros	4	0.2	0.1	0.1
Mazatlán	12	0.3	0.1	0.2
Mérida	7	0.5	0.1	0.2
México, D.F.	1	0.1	0.1	0.1
Nuevo Laredo	4	0.2	0.1	0.2
San Luis Potosí	6	0.5	<0.1	0.2
Tampico	10	0.2	<0.1	0.1
Torreón	10	0.2	<0.1	0.2
Veracruz	15	0.3	0.1	0.2

NS, no sample collected: station temporarily shut down.

4. Pan American Air Sampling Program June 1966

Pan American Health Organization and *U.S. Public Health Service*

Gross beta activity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station locations are shown in figure 5.

Table 5. PAHO gross beta activity in surface air, June 1966

Station location	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	16	0.14	<0.10	<0.10
Chile: Santiago	26	<0.10	<0.10	<0.10
Ecuador: Guayaquil [b]	9	<0.10	<0.10	<0.10
Jamaica: Kingston	25	0.80	<0.10	<0.30
Peru: Lima	17	<0.10	<0.10	<0.10
Venezuela: Caracas	16	0.32	<0.10	<0.12
West Indies: Trinidad	21	0.35	<0.10	<0.18
Pan American summary	130	0.80	<0.10	<0.14

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If more than 10 percent of the samples contain <0.10 pCi/m³, a less-than sign is placed before the average.
[b] Guayaquil, Equador, began reporting data in June 1966.

Figure 5. Pan American Air Sampling Program stations

The June 1966 air monitoring results from the participating countries are given in table 5.

5. National Air Sampling Network April–June 1966

Division of Air Pollution
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. One of the many analyses performed by the NASN on their air samples is for gross beta radioactivity. NASN stations (figure 6) are manned by cooperating Federal, State, and local agencies. The network consists of 110 sampling stations which operation every year and 130 stations which operate every other year. A description of the sampling network was presented in the December 1965 issue of *Radiological Health Data.* Second quarter 1966 gross beta activities in air are given in table 6.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Annual summary 1964	April 1965
Annual summary 1965	April 1966
January–March 1966	July 1966

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(*1*) LOCKHART, L. B., JR., and R. L. PATTERSON, JR. Intercalibration of the major North American networks employed in monitoring airborne fission products, NRL Report 6025. Naval Research Laboratory, Washington, D.C. 20390 (December 1963); summarized in Radiol Health Data 5:12–15 (January 1964).

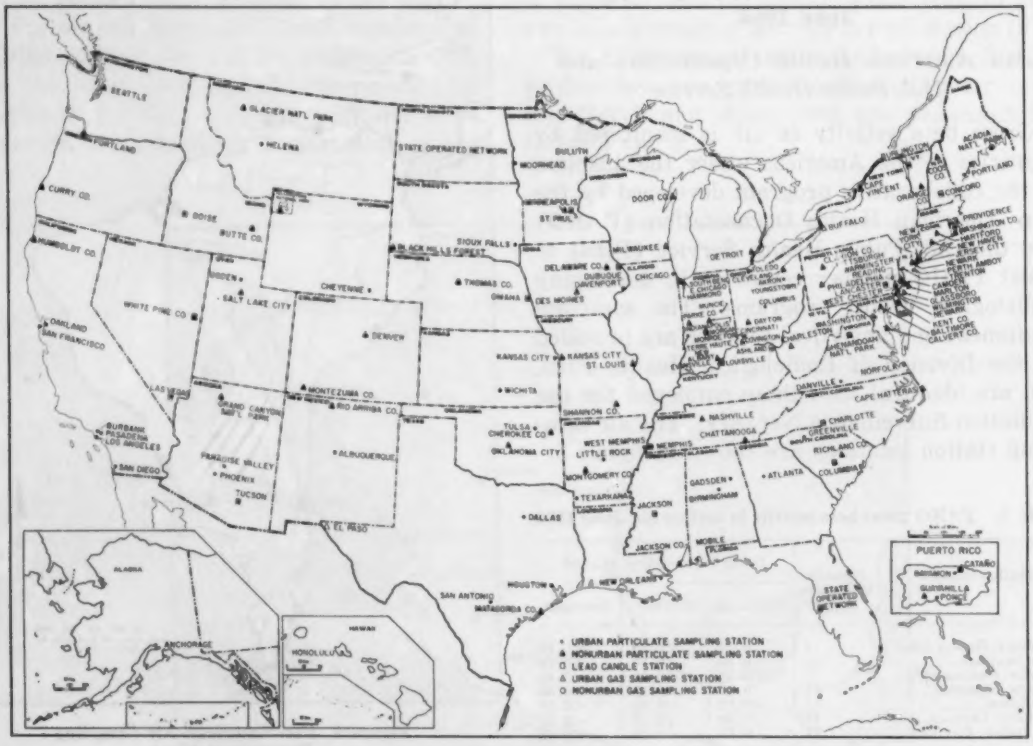

Figure 6. National Air Sampling Network locations, 1966

Table 6. NASN fission product gross beta activity in surface air, April–June 1966

Station name		Number of samples	Concentration, pCi/m³		
			Maximum	Minimum	Average
Ariz:	Paradise Valley	7	10.8	0.1	1.9
	Phoenix	7	7.4	0.2	1.5
	Tucson	7	4.7	0.2	1.1
Ark:	Little Rock	7	1.2	0.1	0.4
	Montgomery County *	7	0.5	0.1	0.3
	Texarkana	6	0.5	0.1	0.3
	West Memphis	6	1.5	0.1	0.5
Calif:	Burbank	7	1.4	0.1	0.3
	Humboldt County *	7	0.2	<0.1	0.1
	Los Angeles	7	4.6	0.1	0.9
	Oakland	7	0.3	0.1	0.2
	Pasadena	7	1.9	0.1	0.5
	San Diego	6	2.2	0.1	0.5
	San Francisco	7	0.4	0.1	0.2
Colo:	Denver	7	1.3	0.2	0.5
	Montezuma County *	7	5.3	0.2	1.3
Conn:	Hartford	7	0.5	<0.1	0.3
	New Haven	7	0.4	<0.1	0.2
Del:	Kent County *	7	0.6	<0.1	0.3
	Newark	6	0.5	0.2	0.3
	Wilmington	6	1.8	0.1	0.5
D. C:	Washington	7	0.6	<0.1	0.2
Ga:	Atlanta	6	1.0	0.1	0.5
Hawaii:	Honolulu	7	1.8	<0.1	0.4
Idaho:	Boise	7	0.6	0.1	0.3
	Butte County *	7	0.8	0.1	0.4
Ill:	Chicago	7	0.6	0.1	0.2
Ind:	East Chicago	7	0.6	0.1	0.3
	Hammond	5	0.5	0.1	0.3
	Indianapolis	7	0.8	0.1	0.3
	N. Monroe State Forest	6	0.5	0.1	0.3
	Muncie	7	0.5	0.1	0.3
	New Albany	6	0.8	<0.1	0.3
	Parke County *	7	0.7	0.1	0.2
	South Bend	7	0.5	0.1	0.3
	Terre Haute	7	0.7	0.1	0.3
Iowa:	Davenport	6	0.8	0.1	0.3
	Delaware County *	7	0.4	0.1	0.2
	Des Moines	7	0.5	0.1	0.2
	Dubuque	7	0.4	0.1	0.2
Kans:	Kansas City	5	0.3	0.2	0.2
	Wichita	7	0.6	0.1	0.3
Ky:	Ashland	7	0.6	0.1	0.3
	Covington	7	0.9	0.1	0.4
	Louisville	7	0.7	0.1	0.3
La:	New Orleans	7	1.4	0.1	0.4
Maine:	Acadia National Park *	6	0.3	0.1	0.2
	Portland	5	0.3	0.1	0.2
Md:	Baltimore	7	0.5	0.1	0.3
	Calvert County *	7	0.4	0.1	0.2
Mich:	Detroit	7	0.5	0.1	0.3
Minn:	Duluth	7	0.5	0.1	0.2
	Minneapolis	7	0.5	0.1	0.2
	Moorhead	7	0.4	0.1	0.2
	St. Paul	6	0.4	<0.1	0.2
Miss:	Jackson	7	0.7	0.1	0.3
	Jackson County *	7	1.1	0.1	0.4
Mo:	Kansas City	7	0.4	0.1	0.2
	St. Louis	6	0.6	0.1	0.3
	Shannon County *	6	0.9	0.1	0.3
Mont:	Glacier National Park *	7	0.9	0.1	0.3
	Helena	7	1.1	0.1	0.3
Nebr:	Omaha	7	0.4	0.1	0.2
	Thomas County *	7	0.8	0.1	0.3
Nev:	Las Vegas	7	5.9	0.1	1.3
	White Pine County *	6	8.6	0.1	1.6
N. H:	Concord	7	0.8	<0.1 0.2	0.3
	Coos County *	6	0.4	0.1	0.3
N. J:	Marlton	7	0.5	<0.1	0.3
	Camden	7	0.4	0.1	0.2
	Glassboro	7	0.5	0.1	0.3
	Jersey City	6	0.6	<0.1	0.3
	Newark	7	0.4	0.1	0.2
	Perth Amboy	6	0.5	0.1	0.3
	Trenton	5	0.3	0.2	0.2
N. Mex:	Albuquerque	7	3.5	0.2	1.0
	Rio Arriba County *	7	1.9	0.1	0.6
N. Y:	Cape Vincent *	7	0.4	0.1	0.2
	New York City	7	0.6	0.1	0.3
N. C:	Charlotte	7	0.8	0.1	0.3
	Cape Hatteras *	5	0.6	0.1	0.3
Ohio:	Akron	7	0.9	0.1	0.4
	Cincinnati	7	0.5	0.1	0.3
	Cleveland	7	0.7	0.1	0.4
	Columbus	7	0.8	<0.1	0.4
	Dayton	7	1.1	0.1	0.4
	Toledo	7	0.8	0.1	0.4
	Youngstown	7	0.8	0.1	0.3
Okla:	Cherokee County *	7	0.5	0.3	0.3
	Oklahoma City	7	0.7	0.2	0.5
	Tulsa	7	0.9	0.1	0.5
Ore:	Curry County *	5	0.2	<0.1	0.1
	Portland	6	0.1	0.1	0.1
Pa:	Clarion County *	6	0.4	0.1	0.2
	Lancaster	7	0.9	<0.1	0.4
	Philadelphia	6	0.6	<0.1	0.3
	Pittsburgh	7	0.6	<0.1	0.3
	Reading	7	0.7	<0.1	0.3
	Warminster	7	0.5	<0.1	0.2
	West Chester	7	0.7	0.1	0.3
P. R:	Bayamón	7	0.7	0.1	0.3
	Guayanilla	7	1.1	0.1	0.3
	Ponce	7	0.5	0.1	0.2
	San Juan	7	1.6	0.1	0.4
R. I:	Providence	6	0.5	0.1	0.3
	Washington County *	5	0.4	0.1	0.3
S. C:	Columbia	7	0.8	0.1	0.3
	Greenville	7	0.6	0.2	0.3
	Richland County *	7	0.4	0.1	0.3
S. Dak:	Black Hills Forest *	6	0.6	0.1	0.3
	Sioux Falls	7	1.8	0.2	0.5
Tenn:	Chattanooga	7	0.7	0.1	0.4
	Memphis	7	0.9	0.1	0.4
	Nashville	6	0.5	0.1	0.4
Tex:	Dallas	7	0.8	0.1	0.4
	Houston	7	1.0	0.1	0.3
	Matagorda County *	6	1.2	0.1	0.4
	San Antonio	7	0.8	0.1	0.3
Utah:	Ogden	7	0.9	0.1	0.4
	Salt Lake City	7	1.9	0.1	0.6
Vt:	Burlington	7	0.9		0.3
	Orange County *	7	0.6	0.1	0.3
Va:	Danville	7	1.4	<0.1	0.5
	Norfolk	5	0.2	0.1	0.1
	Shenandoah Nat'l Park *	7	0.4	<0.1	0.2
Wash:	Seattle	7	0.3	0.1	0.2
W. Va:	Charleston	6	0.5	0.1	0.3
Wis:	Door County *	5	0.2	0.1	0.1
	Milwaukee	7	0.7	0.1	0.3
Wyo:	Cheyenne	7	1.1	0.1	0.5
	Yellowstone Park *	7	1.7	0.1	0.5

* Denotes nonurban station.

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Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

STRONTIUM-90 IN HUMAN BONE SAMPLES, JULY-SEPTEMBER 1965[1]

Division of Radiological Health
Public Health Service

To obtain data on the concentration of strontium–90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. The target population includes children and young adults up to 25 years of age. Since strontium–90 in measurable amounts has been present in the global environment for more than a decade and major calcium accretion ceases by age 17 or 18, persons over 25-years old are of limited interest in the program. This has been confirmed by analyses of selected samples of people in older age groups, the results having shown their bone strontium–90 content to be low and age-independent (*1*).

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available for older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age.

Most specimens received to date have been vertebrae and ribs. Efforts to collect long bones for comparison of results with British data have not been successful.

Laboratory procedures

The bones are analyzed at the Northeastern Radiological Health Laboratory of the Division of Radiological Health, Winchester, Massachusetts. Sample collection and preparation are explained elsewhere (*2*). Strontium–90 is measured by TBP extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium–90 content is then calculated (*3*) from the yttrium–90 activity. For the purpose of maintaining analytical quality control, "blind" duplicate analyses are performed on 10 to 20 percent of the samples. In addition, pools of animal bone ash and adult human bone ash are analyzed in replicate on a continuing basis.

The results of laboratory analyses for strontium–90 in individual bones from persons dying during the third quarter of 1965 are presented in table 1, in order of increasing age within each sampling region. The sampling regions have been defined in an earlier report (*5*). The data are reported as picocuries of strontium–90 per gram of ash (the primary determination) per gram of calcium (for comparison with other data and for purposes of model development) and per gram of bone (as a rough indication of dose). Two-sigma counting errors are reported for the ash concentration. Table 2 summarizes

[1] Period during which death occurred.

Table 1. Strontium-90 in human bone, deaths during July–September 1965

Location of sample by region and State	Sex	Bone type [a]	Age at death [b] (years)	Strontium-90, pCi/g of:			
				Ash	2 σ error	Ca	Bone
Northeast:							
N. Y.	M	V	2	1.05	0.10	2.82	0.08
N. Y.	M	V	2	1.73	0.18	5.19	0.10
Mass.	M	V	3	1.87	0.11	5.26	0.19
N. Y.	M	V	4	0.91	0.16	2.70	0.05
Mass.	M	V	4	1.30	0.11	3.64	0.13
N. Y.	F	V	4	0.83	0.12	2.40	0.05
N. Y.	F	V	5	0.81	0.11	2.23	0.06
Mass.	F	V	7	1.83	0.12	5.25	0.18
Mass.	M	V	7	0.80	0.08	2.20	0.08
Mass.	F	V	10	0.79	0.07	2.21	0.08
Mass.	M	V	11	1.03	0.07	2.92	0.11
N. Y.	M	V	12	0.99	0.11	2.56	0.11
Vt.	M	V	16	1.00	0.07	2.66	0.15
Pa.	M	V	17	0.91	0.06	2.32	0.16
Mass.	M	V	18	0.97	0.06	2.51	0.11
Pa.	M	V	18	0.84	0.07	2.18	0.12
Mass.	M	V	19	0.82	0.07	2.17	0.13
Vt.	M	V	19	1.20	0.07	3.24	0.18
N. Y.	M	V	19	1.02	0.10	2.70	0.12
Pa.	M	V	19	0.72	0.12	1.85	0.13
Vt.	M	V	19	0.90	0.07	2.31	0.13
N. Y.	F	V	19	0.60	0.07	1.57	0.07
Vt.	M	V	19	1.11	0.08	2.95	0.13
Mass.	F	V	24	0.68	0.06	1.73	0.08
N. Y.	M	V	25	0.50	0.05	1.31	0.07
Vt.	M	V	25	0.69	0.05	1.84	0.09
Central:							
Minn.	F	V	4	0.99	0.09	2.76	0.09
Ohio	M	V	4	0.92	0.12	2.44	0.13
Ohio	M	V	5	0.99	0.09	2.55	0.17
Wis.	F	V	5	0.87	0.11	2.45	0.07
Ohio	M	V	6	0.87	0.10	2.31	0.09
Ohio	M	V	10	0.74	0.09	1.94	0.11
Wis.	M	V	10	0.81	0.07	2.27	0.08
Ohio	M	V	12	0.69	0.08	1.86	0.06
Minn.	M	V	15	1.38	0.12	3.83	0.10
Ohio	M	V	16	1.09	0.07	2.85	0.17
Ohio	F	V	17	0.52	0.19	1.31	0.09
Minn.	F	V	18	0.67	0.08	1.75	0.06
Ohio	M	V	21	0.73	0.06	1.91	0.13
Ohio	M	V	22	0.69	0.05	1.83	0.08
Ohio	M	V	23	0.63	0.06	1.64	0.13
Ohio	M	V	25	0.47	0.05	1.20	0.08
Delta:							
La.	F	V	2	2.43	0.14	6.56	0.29
La.	F	V, R	4	1.35	0.11	3.56	0.15
La.	F	V, R	5	1.64	0.11	4.38	0.20
La.	F	V, R	11	0.41	0.11	1.09	0.04
Southwest:							
Calif.	M	V, R, A, I, F	0 (sb) [c]	0.26	0.03	0.69	0.03
Calif.	M	A, F, I	0 (sb) [c]	0.41	0.05	0.11	0.04
Calif.	M	A, F	0 (1 day)	0.31	0.05	0.81	0.04
Calif.	F	V, R, I	0 (7 day)	0.48	0.08	1.28	0.03
Tex.	M	V	1	2.74	0.22	7.77	0.27

[a] Type of bone: V, vertebrae
R, rib
F, femur
I, ilium
A, arm

[b] Age given as of last birthday prior to death.

[c] Stillborn.

all data from 1961 through the third quarter 1965.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–4*).

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Deaths through 1964	April 1966
First Quarter 1965	June 1966
Second Quarter 1965	September 1966

Table 2. Strontium-90 in human bone samples for 5-year-age groups, 1961–1964, and January–September 1965

Age group [a]	Year at death [b]	Number	Strontium-90, pCi/g calcium		
			Mean [c]	Minimum	Maximum
0–4 years	1961	3	2.7	1.8	3.4
	1962	50	3.3	0.8	9.7
	1963	44	4.5	1.0	13.0
	1964	67	4.4	1.0	8.7
	1965, January–September	53	3.9	0.7	8.9
5–9 years	1961	1	2.7	—	—
	1962	33	2.7	1.0	9.4
	1963	43	3.9	1.8	9.1
	1964	64	3.6	1.2	7.0
	1965, January–September	33	3.0	1.3	6.4
10–14 years	1961	4	1.8	1.2	2.8
	1962	28	2.1	0.8	3.5
	1963	47	2.9	1.1	9.0
	1964	56	3.1	0.9	5.7
	1965, January–September	31	2.8	1.1	5.2
15–19 years	1961	0	—	—	—
	1962	31	2.2	0.9	4.6
	1963	73	2.6	1.0	7.0
	1964	58	2.9	1.2	8.0
	1965, January–September	43	2.3	1.3	4.7
20–24 years	1961	0	—	—	—
	1962	29	1.8	0.9	3.5
	1963	61	2.2	0.9	5.0
	1964	52	2.2	0.8	4.3
	1965, January–September	29	1.9	1.0	2.8

[a] Age given as of last birthday prior to death; ages greater than 24 years not included.
[b] Or surgical procedure.
[c] Mean values in this table for the various years within each age group may not be directly comparable because of variations in sampling locations from year to year. However, the data are given as a summary of presently available bone results.

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IODINE-131 IN BOVINE THYROIDS, JULY–DECEMBER 1965

Division of Radiological Health
Public Health Service

To supplement its existing environmental surveillance systems, the Division of Radiological Health established a Bovine Thyroid Network in October 1964 (*1*). Specimens are collected by the Meat Inspection Division, U.S. Department of Agriculture, and analyzed for iodine–131 content at the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

The network consists of collection areas (figure 1) located so as to cover, as nearly as possible, areas near major nuclear reactors, spent-fuel reprocessing plants, and nuclear test sites. Details of sampling and analysis have been published earlier (*1*). For this report, the collection areas (counties) sampled during July through December 1965, were grouped also on a broad geographical basis (figure 1).

The results for July through December 1965, appear in table 1 and are listed chronologically within the geographical groupings in figure 1. The influx of fallout iodine–131 following the mainland China atmospheric nuclear detonation of May 14, 1965, was observed to be generally low (<150 pCi/g thyroid) through July 1965, declining to barely detectable levels in late July 1965. Over the period September 13–14, iodine–131 was observed in several samples collected from counties in California in the Los Angeles area (Fresno, Merced, San Joaquin, Santa Clara) at levels between 50 and 200 pCi/g thyroid. It is suspected that these levels were the result of a release at that time from one of the western nuclear facilities. The observed thyroid activities represent isolated instances which, when evaluated from a public health standpoint, simply indicate the intrusions of low levels of radioactivity into the environment.

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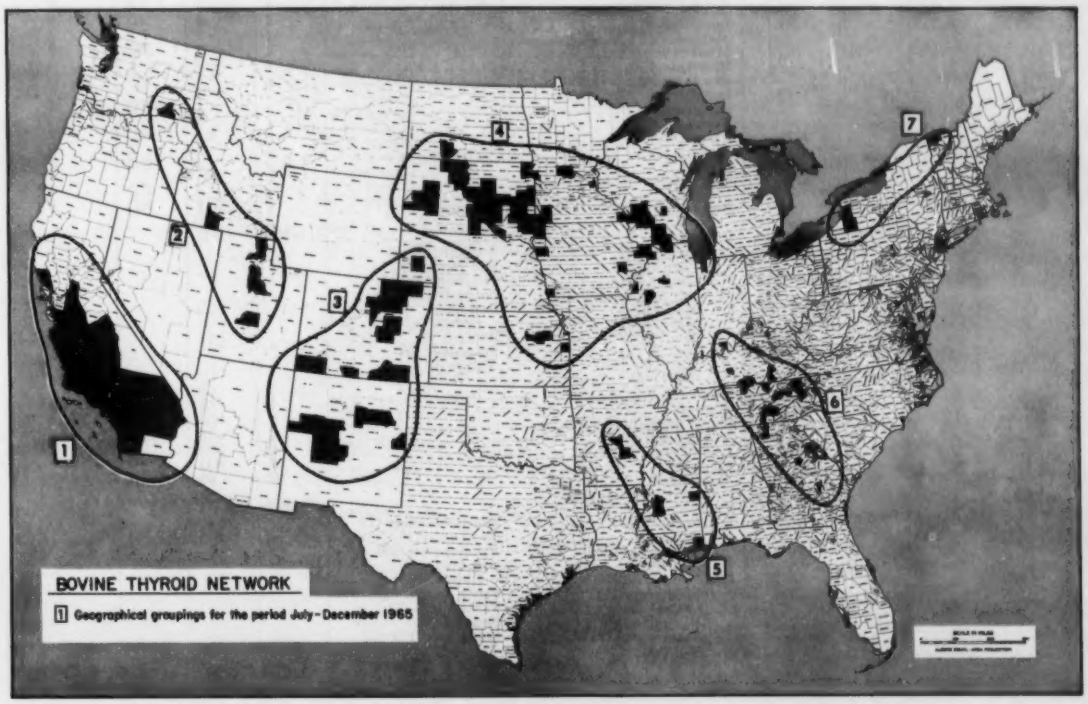

Figure 1. Counties sampled in bovine thyroid network, July–December 1965

Table 1. Iodine-131 in bovine thyroids, July–December 1965

Geographical grouping [a]	Date(s) of slaughter	Counties of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
1 California	7/1	Sacramento	1	38		
		Santa Barbara	2	10	8	12
	7/2	San Joaquin	2	25	21	29
	7/6	Riverside	2	[b] ND		
		Santa Barbara	4	2	ND	3
	7/7	Kern	2	33	21	41
		Los Angeles	1	45		
		San Benito	2	9	8	9
		Santa Clara	2	16	14	17
		Tulare	1	4		
	7/8	Kern	1	8		
		San Joaquin	2	18	12	24
		Stanislaus	1	ND		
	7/9	Merced	1	2		
		Orange	1	30		
		San Bernardino	1	ND		
	7/12	Los Angeles	1	5		
		Madera	4	6	5	7
		Merced	2	9	7	11
		Stanislaus	1	7		
	7/13	Los Angeles	2	ND		
		Merced	1	15		
		San Joaquin	2	16	14	18
	7/14	Kern	1	41		
		Los Angeles	1	3		
		Tulare	1	ND		
	7/15	Ventura	1	6		
	7/16	Orange	2	3	3	3
	7/19	Santa Barbara	1	74		
	7/20	Riverside	3	51	42	58
	7/21	Los Angeles	1	31		
		San Joaquin	2	3	2	4
		Stanislaus	2	1	ND	2
		Tulare	1	2		
	7/22	Fresno	2	3	2	3
		Merced	2	3	2	3
		Tulare	1	ND		
	7/23	Los Angeles	1	ND		
		Orange	1	ND		
	7/26	Los Angeles	1	ND		
		San Benito	2	5	3	6
	7/27	Los Angeles	2	3	ND	6
		Merced	1	3		
		Monterey	2	2	ND	3
		Riverside	1	2		
		San Joaquin	1	4		
	7/28	Los Angeles	1	2		
		San Joaquin	4	<1	ND	4
		Tulare	1	5		
	7/29	Tulare	3	<1	ND	2
	8/2	Madera	2	7	4	10
		Merced	2	2	ND	3
	8/3	Los Angeles	1	ND		
		Madera	2	2	ND	4
		San Joaquin	4	<1	ND	6
	8/4–9/10	[California] [d]	122	[c] ND		
		Fresno (8) [f]				
		Kern (1)				
		Kings (2)				
		Los Angeles (26)				
		Madera (4)				
		Merced (17)				
		Monterey (3)				
		Orange (10)				
		Riverside (4)				
		Sacramento (3)				
		San Benito (2)				
		San Joaquin (13)				
		Santa Barbara (8)				
		San Luis Obispo (4)				
		Sonoma (3)				
		Stanislaus (5)				
		Tulare (9)				
	9/13	Fresno	2	90	ND	179
		Merced	2	103	ND	206
		Santa Barbara	2	ND		
		San Joaquin	2	28	ND	55
	9/14	Los Angeles	2	ND		
		Merced	2	ND		
		Santa Clara	2	95	3	186
	9/15–12/30	[California] [d]	255	[c] ND		
		Fresno (25) [f]				
		Kings (2)				
		Los Angeles (59)				
		Madera (9)				
		Merced (30)				
		Monterey (16)				
		Orange (4)				
		Riverside (15)				
		Sacramento (11)				
		San Benito (2)				
		San Bernardino (1)				
		San Diego (1)				
		San Joaquin (38)				
		San Luis Obispo (1)				
		Santa Barbara (2)				
		Santa Clara (2)				
		Sonoma (3)				
		Stanislaus (11)				
		Tulare (23)				

See footnotes at end of table.

Table 1. Continued—Iodine-131 in bovine thyroids, July–December 1965

Geographical grouping [a]	Date(s) of slaughter	Counties of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
2 Washington, Idaho, and Utah	7/7	Utah	1	60		
	7/10	Utah	2	91	51	131
	7/15	Salt Lake	1	19		
		Utah	1	70		
	7/22	Utah	3	9	[b] ND	17
		Weber	2	4	2	5
	8/3	Walla Walla	10	5	ND	13
	8/10	Walla Walla	5	2	ND	3
	8/20	Walla Walla	6	1	ND	3
	[c] 8/23–12/16	[Utah] [d]	79	[c] ND		
		Cache (5) [f]	[Idaho]			
		Salt Lake (5)	Twin Falls (5)			
		Sevier (5)	[Washington]			
		Utah (10)	Walla Walla (39)			
		Weber (10)				
3 Colorado, New Mexico, and western Nebraska	7/1	Boulder	1	49		
	7/2	Logan	1	22		
	7/6	Bernalillo	6	19	3	55
	7/7	Bernalillo	2	8	6	10
	7/12	Montezuma	4	100	41	146
	7/14	Bernalillo	4	10	3	22
	7/19	Curry	4	81	6	149
	7/20	Bernalillo	4	38	2	119
	7/26	Bernalillo	4	3	ND	7
	7/27	Valencia	4	4	ND	8
	8/2	Adams	4	4	2	5
		Bernalillo	4	2	ND	4
	8/4	Curry	4	9	3	12
	8/9	La Plata	4	3	2	3
	8/10	Las Animas	1	5		
	[c] 8/12–12/28	[Colorado] [d]	226	[c] ND		
		Adams (0) [f]	Morgan (2)			
		Boulder (0)	Weld (2)			
		Conejas (8)	[New Mexico]			
		Denver (2)	Bernalillo (47)			
		El Paso (12)	Curry (39)			
		Jefferson (1)	San Miguel (13)			
		La Plata (27)	Socorro (4)			
		Las Animas (0)	Valencia (9)			
		Logan (16)	[Nebraska]			
		Montezuma (8)	Morrill (36)			
4 North Dakota, South Dakota, Minnesota, Iowa, Illinois, Wisconsin, Kansas, and northwest Indiana	7/8	Sioux	9	22	ND	116
	7/13	Dewey	10	60	3	132
	7/22	Deuel	2	38	36	39
	7/23	Turner	1	ND		
	7/30	Sauk	3	5	3	7
		Nobles	6	3	ND	7
	8/6	Brookings	4	ND		
	8/11	Charles Mix	1	2		
		Hanson	5	1	ND	2
		Lake	4	3	ND	8
	[c] 8/17–12/29	[South Dakota] [d]	265	[c] ND		
		Aurora (9) [f]	Jerwauld (2)			
		Beadle (1)	Kingsbury (5)			
		Brookings (19)	Lake (0)			
		Brown (18)	Lincoln (1)			
		Brule (1)	Lyman (1)			
		Buffalo (1)	McCook (3)			
		Charles Mix (0)	Meade (1)			
		Corson (11)	Miner (4)			
		Deuel (2)	Minnehaha (17)			
		Dewey (0)	Pennington (1)			
		Faulk (1)	Roberts (2)			
		Hamlin (9)	Sully (5)			
		Hand (7)	Tripp (1)			
		Hanson (1)	Turner (0)			
		Hughes (1)	[North Dakota]			
		Hyde (1)	Grant (2)			

See footnotes at end of table.

Table 1. Continued—Iodine-131 in bovine thyroids, July–December 1965

Geographical grouping [a]	Date(s) of slaughter	Counties of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
4 continued.	8/17–12/29	[Indiana] [d] Porter (2) [f] [Minnesota] Big Stone (2) Houston (1) Murray (1) Nobles (0) Ramsey (6) Rock (1) Stearns (2) [Kansas] Geary (2) Miami (1) Shawnee (15) Wabaunsee (1) [Wisconsin] Dane (18) Green (6) Green Lake (1) Juneau (1) Monroe (3) Richland (3) Rock (34) Sauk (7) Vernon (1) [Illinois] Boone (2) Carroll (6) Fulton (5) Henderson (1) Jo Davies (1) Marshall (1) Winnebago (1) [Iowa] Fremont (9) Jackson (1) Johnson (1) Lyon (1) Sioux (0) Woodbury (1)				
5 Arkansas and Mississippi.	7/30	Pulaski	3	7	4	12
	8/10	Jefferson	1	4		
		Pulaski	1	2		
	[e]8/11–12/15	[Mississippi] [d] Copiah (3) [f] Hinds (5) Jackson (15) Lauderdale (5) [Arkansas] Jefferson (0) Pulaski (0)	28	[e] ND		
6 Tennessee, Kentucky, Georgia, southern Indiana, and western North Carolina	7/13	Clay	1	14		
	7/14	Hawkins	1	12		
		Jefferson	2	22	17	27
		Richmond	3	3	3	3
	7/29	Greene	1	11		
	7/30	Greene	5	9	7	10
	8/3	Hawkins	1	3		
	8/4	Jackson	2	5	4	5
	8/5	Richmond	2	[b] ND		
	8/6	Putman	1	ND		
	8/9	Bradley	4	4	ND	7
	8/10	Edmonson	3	4	ND	10
	8/13	Greene	2	4	ND	8
	8/23	Greene				
	[e]8/25–10/4	[Tennessee] [d] Bradley (0) [f] Clay (1) Greene (4) Hawkins (1) Jackson (0) Jefferson (0) Knox (2) McMinn (2) Meigs (1) Monroe (7) Scott (1) [Kentucky] Clinton (1) Cumberland (2) Edmonson (1) Laurel (1) Monore (1) Whitley (1) [Indiana] Crawford (1) [North Carolina] Madison (1) [Georgia] Gordon (1) Lincoln (1) McDuffie (1) Montgomery (1) Murray (2) Putman (3) Richmond (1) Wilkes (5)	43	[e] ND		
7 New York and Vermont.	7/13	Franklin	19	12	ND	43
	7/22	Cattaraugus	4	13	8	17
	7/26	Franklin	10	13	7	23
	7/27	Franklin	10	<1	ND	3
	7/29	Cattaraugus	7	9	5	15
	8/5	Cattaraugus	5	2	ND	5
	8/9	Franklin	20	1	ND	3
	8/12	Cattaraugus	8	3	ND	4
	8/19	Cattaraugus	4	2	ND	4
	[e]8/23–12/28	[Vermont] [d] Franklin (166) [f] [New York] Cattaraugus (43) Erie (36)	245	[e] ND		

[a] Geographical areas as designated in figure 1, encompassing those counties that were sampled in the States indicated.

[b] ND-Not detectable; the two standard deviation counting error was greater than or equal to the concentration observed. For the counting system utilized, the two standard deviation counting errors were generally 1–3 pCi/g thyroid.

[c] Samples were not collected on all dates included during this period, but the interval brackets several sampling dates.

[d] Brackets give State and are followed by counties sampled during the period indicated.

[e] The results for this period were for the most part not detectable. Some positive results were obtained, but represented barely detectable amounts of iodine-131 in the bovine thyroid. In general these positive results were 2–7 pCi/g thyroid and randomly scattered over the time periods and counties indicated.

[f] Numbers in parentheses represent number of samples collected from each county during the interval indicated. These may have been collected over several dates during the period or on only one date. (0) indicates county sampled but not during the given period.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations.[1] The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[2]

Summaries of environmental radioactivity data follow for the Bettis Atomic Power Laboratory, Feed Materials Production Center, Knolls Atomic Power Laboratory, and the S1C Prototype Reactor Facility.

[1] Copies of these reports are available from the Division of Public Information, Atomic Energy Commission, Washington, D.C. 20545.

[2] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

1. Bettis Atomic Power Laboratory July–December 1965[3]

Westinghouse Electric Corporation
Pittsburgh, Pennsylvania

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by the Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and to the central station power reactor at Shippingport, Pennsylvania. Routine environmental monitoring data from the sampling locations shown in figure 1 show no significant contribution from laboratory operations to environmental radioactivity levels.

Liquid radioactive waste

Liquid effluent discharged from the laboratory is sampled continuously. Composite samples are analyzed weekly for gross alpha and gross beta-gamma activity, and quarterly for strontium–90 activity.

The average concentration of gross beta radioactivity in the main laboratory liquid effluent during the second 6 months of 1965 was 650 pCi/liter. This was lower than the average concentration of 3,000 pCi/liter observed in the first half of 1965. The average concentration of strontium–90 for this period was 20 pCi/liter, which is lower than the concentration of 110 pCi/liter for the first 6 months of 1965. The gross radioactivity concentration in the critical facility effluent averaged 1,500 pCi/liter, which was higher than the average concentration of 920 pCi/liter for the first 6 months of 1965.

Background monitoring stations

Beta-gamma background radiation levels were continuously monitored and recorded at monitoring stations located at the periphery of the laboratory property. The use of background monitoring stations was terminated as of November 14, 1965, and 34 film badges were located on the peripheral fence at 100-yard intervals. These badges were collected on January 25, 1966, and the average background radiation levels were determined for the period from November 11, 1965, through January 25, 1966. In the future, badges will be collected and read quarterly or immediately following an accidental environmental release or radiation incident.

The results obtained from the beta-gamma background monitoring stations during the

[3] Summarized from "Environmental Radioactivity at the Bettis Atomic Power Laboratory for the Second Six Months of 1965 and for Calendar Year 1965" (PNR–DEV–136).

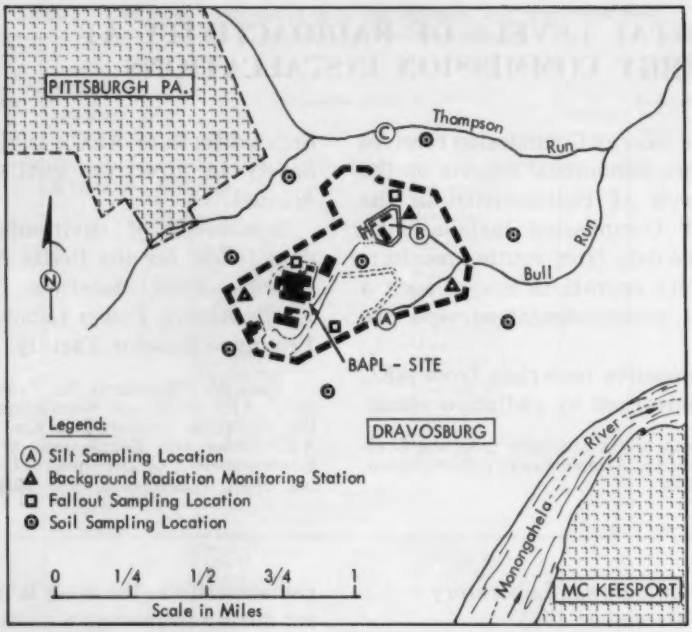

Figure 1. Bettis Atomic Power Laboratory sampling stations

period July to November 14, 1965, are summarized in table 1.

There was an increase of 0.022 mR/hour in the mean beta-gamma background radiation level for the period July to November 14, 1965, as compared to the results for the first 6 months of 1965. This was due to the higher background levels at station 4, which were due to the close proximity of the station to a critical test facility.

Table 1. Beta-gamma radiation, background monitoring stations, July–November 14, 1965

Exposure levels (mR/hr)	Station		
	1	3	4
High weekly average	0.100	0.057	0.182
Low weekly average	0.012	0.010	0.032
Mean	0.018	0.014	0.061

The results obtained from the film badge monitors during the period from November 11, 1965, to January 25, 1966, are summarized in table 2.

Fallout

Fallout samples are collected at three locations at the perimeter of the laboratory. Samples are collected over a period of 1 month in high-wall, stainless-steel pots, and are analyzed for gross beta activity. The average monthly concentration of radioactive fallout for the second half of 1965 was 3.98 nCi/m^2. This value is essentially the same as the average monthly concentration of 3.86 nCi/m^2 for the first 6 months of 1965.

Table 2. Beta-gamma radiation, film badge monitors November 11, 1965–January 25, 1966

Area	Exposure levels, mR/hr	
Main laboratory area (20 locations)	Maximum	0.230
	Minimum	0.003
	Average	0.034
Critical facility area (14 locations)	Maximum	0.033
	Minimum	0 011
	Average	0.020
All locations	Average	0.028

Soil samples

Soil samples were collected at the eight locations shown in figure 1. These samples are not routinely analyzed. The collection of soil samples was discontinued in November 1965.

Stream silt

Stream silt samples were taken quarterly at the three locations shown in figure 1. The results of analysis of these samples are presented in table 3.

Table 3. Radioactivity in stream silt, July–December 1965

Period	Location	Silt concentrations (pCi/g)	
		Alpha	Beta-gamma
Third quarter, 1965	A	25	1,100
	B	20	22
	C	41	20
Average		29	380
Fourth quarter, 1965	A	30	180
	B	19	33
	C	25	26
Average		25	80
Second half, 1965 Average		27	230

The average alpha concentration in the stream silt samples was not significantly different from the concentration of 29 pCi/g for the first 6 months of 1965. However, the average beta-gamma concentration was higher than the concentration of 85 pCi/g for the first 6 months of 1965. This was the result of the higher concentration in the third quarter sample from location A, which was probably due to the higher beta-gamma concentrations in the main plant's liquid effluent being discharged near location A.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July 1962–June 1963	April 1964
July 1963–December 1963	November 1964
January–June 1964	April 1965
July–December 1964	October 1965
January–June 1965	April 1966

2. Feed Materials Production Center July–December 1965[4]

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 2. Cincinnati and Hamilton—the larger nearby communities—are situated 20 and 10 miles, respectively, from the center. Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium, and with fabricating the metal into fuel elements.

An environmental survey program of air and water sampling is maintained to check the effectiveness of dust collectors and waste treatment processes. Inspection of the data indicates that releases of radioactive materials to the environment is controlled as required by AEC and State of Ohio regulations.

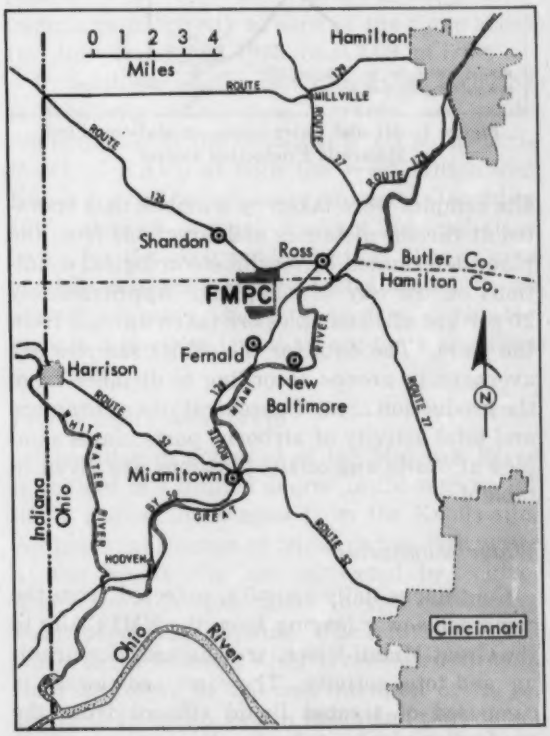

Figure 2. Area map of Feed Materials Production Center

[4] Summarized from "Feed Materials Production Center Environmental Monitoring Semi-Annual Report for the Second Half of 1965" (NLCO–972).

Air monitoring

FMPC uses dust collectors such as bag collectors, electrostatic precipitators, and scrubbing towers which remove nearly all of the airborne particulates generated during the main plant operations. The environmental air sampling program provides an indication of the amount of material released into the atmosphere.

Onsite samples were taken at four permanent sampling stations located at the four corners of the production area shown in figure 3. Offsite samples were taken by a mobile unit operated at various distances and directions from the plant determined by local meteorological conditions on the day of sampling. Approximately 20 percent of all samples are taken upwind from the plant. The data for the offsite samples are averaged in groups according to distance from the production area. Concentrations of uranium and total activity of airborne particulates sampled at onsite and offsite locations are given in table 4.

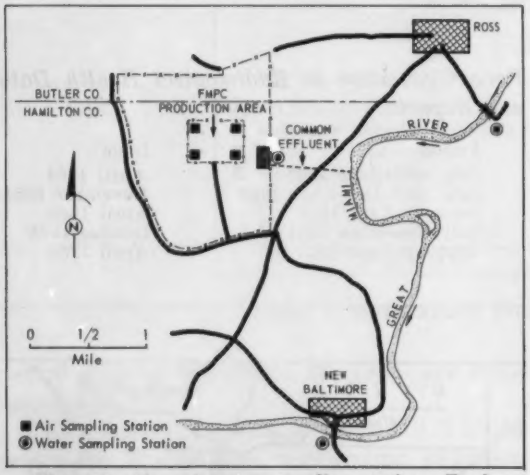

Figure 3. Air and water sampling stations, Feed Materials Production Center

Water monitoring

Continuous daily samples, collected from the combined sewer leading from the FMPC site to the Great Miami River, are analyzed for uranium and total activity. The combined sewage is composed of treated liquid effluent from the production plants, water treatment plants waste effluent, storm sewer discharge, and treated sanitary sewage. Using the data from the combined sewage samples and stream flow data for the Great Miami River, the FMPC contribution to radioactivity concentrations in the river may be calculated. To check the calculated results, weekly upstream and downstream spot samples are taken at the locations shown in figure 3. Table 5 presents the calculated and the spot check river concentrations. Since the calculated concentration represents only the contribution from FMPC, it should be compared with the difference between the upstream and downstream measurements.

Table 4. Radioactivity levels of airborne particulates July–December 1965

Location	Number of samples	Average concentrations, pCi/m³	
		Uranium	Total activity
Onsite:			
Southwest	27	<0.1	0.2
Northwest	27	<0.1	0.1
Northeast	27	0.1	0.3
Southeast	27	<0.1	0.2
All onsite samples	108	0.1	0.2
Offsite:			
0–2 miles from FMPC	20	<0.1	0.4
2–4 miles from FMPC	16	<0.1	0.1
4–8 miles from FMPC	19	0.1	0.2
8–12 miles from FMPC	12	<0.1	<0.1
All offsite samples	67	0.1	0.2
AEC Standard		2.0	100

Table 5. Concentrations of uranium and total activity in the Great Miami River, July–December 1965

Location	Method of determination	Number of samples	Average concentrations (pCi/liter)	
			Uranium [a]	Total activity [b]
Sewer outfall	Calculated from sewer concentrations and stream data (continuous sampling).	184	3	10
Upstream	Spot samples	30	5	50
Downstream	Spot samples	34	14	60
Difference			9	10
AEC Standard			20,000	3,000

[a] MPC, 20,000 pCi/liter
[b] MPC, 3,000 pCi/liter

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July 1961–June 1962	March 1963
July 1932–December 1963	May 1964
January–June 1964	April 1965
July–December 1964	October 1965
January–June 1965	April 1966

3. Knolls Atomic Power Laboratory July–December 1965[5]

General Electric Company
Schenectady, New York

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission, is to support the Naval Reactors Program of the Atomic Energy Commission in the development of atomic power for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the West Milton site, located as shown in figure 4. The Knolls site occupies approximately 170 acres on which are located adminstrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; critical assembly buildings; machine shops; decontamination facilities; radioactive waste storage and processing facilities; and nuclear fuel storage and assembly buildings. The West Milton site occupies approximately 4,000 acres. Its principal facilities include the Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building, and waste treatment facilities. Regular environmental monitoring activities are conducted to assure that laboratory releases of radioactivity to the environment are in compliance with AEC standards. The data that follow indicate that laboratory waste operations have complied with AEC requirements.

[5] Summarized from "Knolls Atomic Power Laboratory Semiannual Environmental Monitoring Report, July–December 1965" (Volume 7, Number 2).

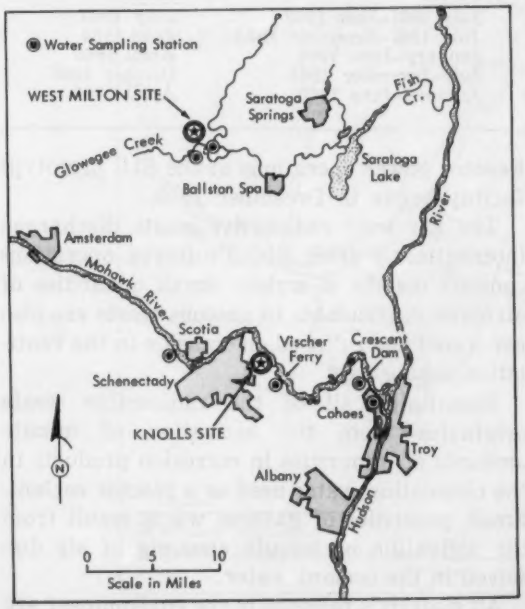

Figure 4. Environmental monitoring locations, KAPL

Air monitoring

Environmental airborne radioactivity is measured at two locations on the Knolls site, four locations at the West Milton site, and at the General Electric Company Research Laboratory approximately 1 mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis. Each environmental monitoring station is equipped with film dosimeters to detect integrated gamma radioactivity levels. The average airborne beta-gamma radioactivity at each of the three areas for July–December 1965 was 0.09 pCi/m^3.

In addition to the environmental airborne radioactivity monitoring, surveys are made semiannually of the radiation levels at the perimeter of KAPL at both the West Milton and Knolls sites. The perimeter survey of December 1965 showed normal background radiation levels for the geographic location. The results of this perimeter survey, extrapolated to an annual exposure, indicate average perimeter radiation levels of less than one-tenth roentgen per year.

Liquid waste monitoring

The dilution potential of the Mohawk River is utilized to a limited degree in the disposal of liquid radioactive wastes from the Knolls site. All potential sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The release of liquid waste to the Mohawk River is regulated through the monitoring of the concentration of fission products in the collection tanks and the control of the discharge rate of the effluent. A continuous proportional sample of the Knolls site

combined sewer effluent is taken at the point of discharge to the Mohawk River. Radiochemical analyses of weekly composite samples show that strontium–90 is the principal component to be considered in control. The amounts and the radionuclide content of the combined sewer effluent discharged from the Knolls site have been summarized in table 6. A total of 329 millicuries of beta activity was discharged to the Mohawk River during the 6-month period at monthly average concentrations ranging from 270 to 720 pCi/liter.

Table 6. Radionuclide concentrations in the Knolls site waste effluent, July–December 1965

Radionuclides	Concentration (pCi/liter)	AEC standard (pCi/liter)
Strontium-89	<4.2	3,000
Strontium-90	160	300
Yttrium-90	100	2,000
Ruthenium-106	<4.2	10,000
Iodine-131	<4.2	300
Cesium-137	110	20,000
Cerium-praseodymium-144	30	10,000

Since Glowegee Creek does not have a reliable dilution potential, the radioactivity levels in the liquid waste from the West Milton site are operationally controlled and diluted prior to release to the creek. A total of 3.02 millicuries was discharged at two points into Glowegee Creek during the six-month period at monthly average concentrations ranging from 6 to 77 pCi/liter. Samples of the Glowegee Creek water are taken once a week at two locations, one at about 150 feet above the point where the S3G effluent enters the stream, and the other 2,640 feet below the S3G discharge or 1,500 feet below the D1G discharge.

Mohawk River water is sampled continuously at the point of disharge from the Knolls site; at the General Electric Company powerhouse eight miles upstream from the site; at the Vischer Ferry powerhouse approximately two miles downstream; and at the City of Cohoes pumping station about 13 miles downstream. Results are given in table 7.

Table 7. Gross beta-gamma activity in streams receiving effluents, July–December 1965

Streams and sampling locations	Concentration (pCi/liter)	AEC standard (pCi/liter)
Mohawk River (Knolls site)		100
G.E. powerhouse (upstream)	8	
Vischer Ferry (downstream)	7	
Cohoes (downstream) raw water	8	
Cohoes (downstream finished drinking water	5	
Glowegee Creek (West Milton site)		3,000
Upstream	4	
Downstream	7	

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July 1961–June 1962	July 1963
July 1962–December 1963	June 1964
January–June 1964	April 1965
July–December 1964	October 1965
January–June 1965	April 1966

4. S1C Prototype Reactor Facility July–December 1965[6]

Combustion Engineering, Inc.
Windsor, Connecticut

The S1C Prototype is a land-based nuclear submarine power plant operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, Inc. The prototype contains a pressurized water reactor power plant which is used to conduct research and development work and to train personnel in the operation of naval reactor power plants. Reactor power operations at the S1C prototype facility began in December 1959.

The low level radioactive waste discharged intermittently from S1C Prototype operations consists mainly of water. Small quantities of airborne particulates in gaseous waste are also generated and released on occasion in the ventilation exhaust air.

Essentially, all of the radioactive waste originates from the activation of minute amounts of impurities in corrosion products in the circulating water used as a reactor coolant. Small quantities of gaseous waste result from the activation of minute amounts of air dissolved in the coolant water.

All materials released to the environment are routinely monitored to assure that waste dis-

[6] Summarized from "S1C Prototype Reactor Facility Environmental Monitoring Report, July 1 to December 31, 1965" (CENRD–3163–RS–531).

posal operations comply with AEC regulations. Monitoring results which follow indicate that the facility has fully complied with the prescribed standards of the AEC.

Air monitoring

Ventilation air from the submarine hull and the supporting facility at the prototype site may, at times, contain small amounts of airborne radioactive particulate or gaseous activities. This ventilation air is discharged to the environment through an exhaust stack. The ventilation air is continuously monitored for radioactivity by particulate and gaseous counters which control the discharge of the air. Alarms are sounded if the concentration approaches permissible limits. When these limits are exceeded, the exhaust air is discharged through a high-efficiency filter bank or the ventilation system is completely shut down and the hull sealed. In addition, air is sampled for particulates at several locations onsite and offsite. Table 8 presents the average gross beta activities in air.

Table 8. Gross beta activity in air, S1C, July–December 1965

Sampling locations	Average concentrations pCi/m³)
Stack and hull effluent	60
Onsite samples	0.35
Offsite samples	0.45

Water monitoring

Liquid wastes are collected in 5,000-gallon retention tanks. When a tank is full, it is sampled and analyzed for its radioactivity content. If the activity is below the allowable discharge limit, the tank contents are released into the industrial waste system. If the limit is exceeded, the contents are diluted below acceptable limits in a 25,000-gallon dilution tank and then released. Table 9 is a summary of the gross radioactivity released to the Farmington River.

The Farmington River is sampled periodically at various locations as shown in figure 5 for determination of gross beta activity in river water and mud. All 25 water samples contained

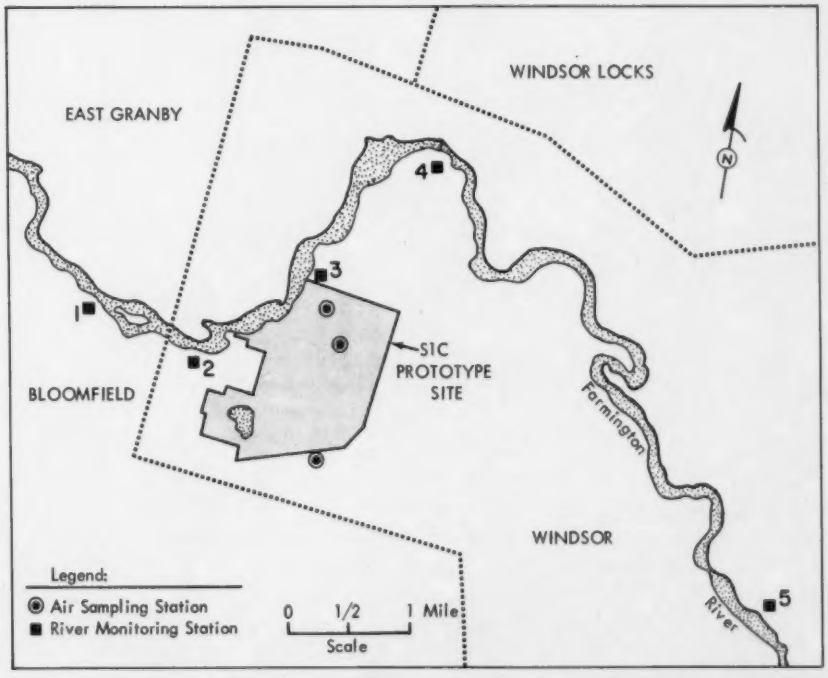

Figure 5. Environmental monitoring locations, S1C Prototype site

Table 9. Radioactivity in liquid wastes discharged into the Farmington River, S1C, July–December 1965

Activity	Quantity
Total beta activity (millicuries)	21.9
Average concentrations (pCi/liter):	
Gross beta	5,800
Cobalt-60	4,200
Iron-59	810
Manganese-54, cobalt-58	1,500

less than the detectable level of 10 pCi gross beta/liter. All seven mud samples contained less than the detectable level of 10 pCi gross beta/gram.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1961	March 1962
July 1961–June 1962	July 1963
July 1962–December 1963	June 1964
January–June 1964	April 1965
July–December 1964	October 1965
January–June 1965	April 1966

Section V. Technical Notes

REPORTED NUCLEAR DONATIONS, SEPTEMBER 1966

During September 1966, three U.S. nuclear tests, all conducted underground at the Nevada Test Site, were announced by the U.S. Atomic Energy Commission.

A test of low yield (less than 20 kilotons TNT equivalent) was conducted on September 12; a test of low-intermediate yield (20 to 200 kilotons TNT equivalent) was conducted on September 23; and a test of low yield was conducted on September 29.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

DIGEST OF HEALTH STANDARDS AND STATE REGULATIONS FOR RADIOACTIVITY IN WATER. *J. L. S. Hickey. Radiological Health Data and Reports, Vol. 7, October 1966, pp. 549–554.*

Numerical limits of seven published standards and guides for radium–226, strontium–90, and unidentified radionuclides in water for various applications and population groups are summarized. Of the 54 States and Territories, 47 have legislation or regulations for control of radionuclides in water. Of these, 31 have adopted some form of numerical limits for control of radionuclides in water. Sixteen States and Territories have general legislation permitting control of radiation exposure but no numerical limits for radionuclides in water, and seven have no specific legislation for control of radionuclides in water.

KEY WORDS: Atomic Energy Commission, Council of State Governments, Federal Radiation Council, International Commission on Radiological Protection, National Committee on Radiation Protection, Public Health Service Standards, radium–226, strontium–90, water, World Health Organization.

PRECISION AND SENSITIVITY OF GAMMA SPECTROMETRIC MEASUREMENTS IN MILK. *M. A. Wall* and *A. S. Goldin. Radiological Health Data and Reports, Vol. 7, October 1966, pp. 555–559.*

The performance of a gamma spectrometric laboratory comprised of four closely similar detector-analyzer systems was evaluated by examining the results obtained on environmental fluid milk samples. The sensitivity of the system was evaluated by measurements of iodine–131 concentrations, mostly at the zero counting level. The precision of the system was measured on the basis of replicate determinations of potassium and cesium–137 at higher counting levels.

At low and intermediate levels, variability was not significantly different from that calculated from radioactivity statistics. Only at the highest level encountered was there any indication of a greater variability than would be expected from these statistics, and even at this level the difference was not significant at the 95-percent confidence level.

KEY WORDS: barium–140, cesium–137, counting error, gamma spectrometry, iodine–131, milk, Poisson distribution, precision, sensitivity.

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SYMBOLS, UNITS, AND EQUIVALENTS

Symbols	Units	Equivalents
BeV	billion electron volts	equals GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volts	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi per square meter (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi per square mile
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs per gram

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	decĭ	d	dĕs' ĭ
10^{-2}	centi	c	sĕn' tĭ
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mī' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

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